A Study of Some Factors Entering into the Determination of Handedness

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THE essential nature of this study is that of a fact finding investigation of some theories of causes of handedness and of alleged relationships within the infant groups.

In another paper not yet published, I made a purely statistical analysis and interpretation of degrees of handedness in three age groups,—namely, kindergarten children, sixth grade children and college students. One conclusion reached there, which is pertinent to this study, is as follows:

> "In view of the results presented . . . . , it would seem practically certain that the handedness index of a group of infants, as measured by the tapping test or some other test of what might be called native handedness, would be distributed normally, that is, that log R/L would be distributed normally."

In other words, the statistical analysis and interpretation referred to above indicates that the frequency distribution of the symmetrical index of handedness, log R/L, where R is the count for the right hand and L is the count for the left hand for a similar type of performance, obeys the normal frequency law at birth. This conclusion indicates that there is no "single cause" for what might be called native right and left handedness. This does not mean, however, that the frequency curve of an adult group will follow the normal law, for when the test used is a test of acquired ability such as that given by a writing test or a number marking test, the frequency distribution obeys quite a general frequency law which in no sense of the word can be called normal. Hence, one must be careful to distinguish between the accompaniments of left handedness and the causes of it.

Literature abounds with theories of the "causes" of dextrality. Some appear, on the surface, to be quite plausible, for instance, the theory of M. van Biervliet (4). On the basis of a very limited sample, he contended that there exists a symmetry of strength of reaction for all sense organs on a given side, and that when dextrality is dominant, the reaction is about one ninth stronger on the right side, whereas when sinistrality is dominant, the reaction is about one ninth stronger on the left side. He announced that he had established this relation for muscular reaction, vision, audition and touch.

Then, there is the theory of G. M. Gould (2), who maintained that all purposive movements followed the sighting eye. However, he postulated the actuality of the "sighting eye, without experiment." T. L. Woo and Karl Pearson (5) using the data on 7,000 subjects collected by Francis

Galton recently have undisputedly shown that these two theories are not supported by facts.

Also, there are theories which maintain that brain sidedness has a determining effect on handedness (1). However, if left brainedness should be found to be associated with right handedness, it could then be postulated to be either the cause or the accompaniment of right handedness. If it is the cause, and if as is indicated by my study mentioned above, the index of handedness is distributed normally at birth, then degrees of left brainedness would have to be distributed normally, and we would not, therefore, have any greatly explanatory information regarding the cause of right handedness until we knew the cause of left brainedness.

Moss (3) made the observation that there was a parallelism between the percentage of right handedness and the percentage of a certain type of birth presentation. He pointed out that, as is well known, during the last three to six weeks before birth the position of the foetus becomes relatively fixed, and that, in head presentations, which make up the greater percentage of all deliveries, the left arm is pinned against the mother's bony parts and the right arm is free to move, or the right arm is impinged against the mother's bony parts and the left arm is free. He noted that the percentage of babies that have the presentation position in which the left arm is in a fixed position and the right arm free corresponds roughly with the percentage of right handedness found in adult life, and, consequently, that the percentage of babies that have the presentation position in which the right arm is in a fixed position and the left arm free, corresponds roughly with the percentage of left handedness found in adult life. In order to carefully investigate this observation he secured the kind and effective coöperation of Dr. H. W. Lawson, former professor and head of the Department of Obstetrics at George Washington University, and of Dr. Howard Kane, Professor of Obstetrics at George Washington University. I desire to express my appreciation and gratitude to Dr. Fred A. Moss for his helpful advice and guidance in this study. These men kept a detailed record of the position of the foetus during the last part of pregnancy—in most cases the records were especially detailed for the last three months of pregnancy—and, in addition, other material concerning those prenatal factors which might be supposed to be related to handedness.

A total of 486 cases were studied in an endeavor to ascertain the relation, if any of the presentation position of the foetus to dextrality and of other possibly related prenatal factors to dextrality. There were 330 cases in the Kane group, and 156 more in the Lawson group.

By means of a test which was objective in all its phases save one, namely, that each mother tested her own child, the 486 babies ranging in age from six months to two years were tested for handedness. It was found that 18.3 per cent were left handed, and 81.7 per cent were right handed. It is well to point out here that the subjective element in this test probably

favors the percentage for right handedness, inasmuch as there is a tendency for most people to consider left handedness as an undesirable trait, and hence, most mothers would be desirous of having their children test with right handed reactions if possible. It is also most important to point out that the test, as it was used by the mothers, does not measure degrees of handedness. However, the test was conceived in the anticipation that degrees of handedness should be measured through its application. It was only because there was so much irregularity in the reports as given by the mothers that it was impossible to plot a frequency curve from their results. Each mother used the test only long enough to prove to her satisfaction that her child was either right or left handed, failing to realize that a very important bit of data would have been gained could it have been ascertained just how much right handed and how much left handed her child really was. However, for the immediate purposes of this study the broad demarcations of the child's being either right or left handed are quite sufficient.

A description of the test used is as follows: Two government penny postal cards on the same sheet of cardboard were folded together. One card contained the following instructions on the side not used for the address of the mother:

"1. On each of four days offer your child ten times each day some object he desires.

"2. Hold the desired object directly in front of your child so that no preference can be given either hand.

"3. Record on the accompanying record card the number of times your child reaches with his right hand and the number of times with his left."

The other card contained the author's address on one side, and on the opposite, a record for 1 and 2 above and also the following questions:

"Are any of your child's relatives left-handed? ——.

"Approximately at what age did your child have the first tooth? ——."

Factors which might influence handedness both prenatally and postnatally were considered. Four prenatal factors possibly related to handedness were investigated, the first of which was the dominant position of the foetus before birth and the presentation position of the child at birth. The seemingly feasible theory which led to this investigation has been indicated above.

A concise picture of the results of this study of 486 cases is given in table 1.

It will be observed that 89.6 per cent of the 486 observations fall within the LOA and ROA groups and that 83.2 per cent of these cases in the LOA and ROA groups are right handed, and that of the total 486 observations, 81.7 per cent are right handed and 18.3 per cent are left handed. Furthermore, 81 per cent of the LOA group and 79 per cent of the ROA group are right handed in the 330 observations; and in the 156 observations, 85 per cent of the LOA and 90 per cent of ROA are right handed. The percentage of right handednesss is so nearly the same for both major birth positions that the results of this section of the study seem clearly to indicate that the dominant position of the child in the uterus of the mother, and the birth presentation position of the child are not causally related

to its dextrality. This result, however, is exactly what should be expected in view of the indicated normal frequency curve for the dextrality of infants mentioned at the beginning of this paper.

Since certain factors, such as birth weight, metabolic rate of the mother, etc., which are known to influence the movement of the infant in the uterus were not taken into account, further studies of these factors were made.

of the hyperthyroid mother might be inclined to move about a great deal, and thus to move its arms both more vigorously and more often than the child of the hypothyroid mother.

It was found that within the 156 basal metabolism observations, the average basal metabolism of the mothers of 6 ambidexterous children was −7.3, and of mothers of 25 left handed children was −5.8, and of mothers of 125 right handed children was −3.7. From these results it

TABLE 1

A study of presentation position and handedness

	DELIVERY POSITION																							
	LOA			ROA			LSA			LSP			RSP			RSA			ROP			LOP		
Handedness.....	R	A	L	R	A	L	R	A	L	R	A	L	R	A	L	R	A	L	R	A	L	R	A	L
Number.....	157	5	32	86	3	20	7	0	2	4	0	1	4	0	1	2	0	0	4	0	2	0	0	0
Per cent of 330....	81	3	16	79	3	16	78	0	22	80	0	20	80	0	20	100	0	0	67	0	33	0	0	0
Number.....	78	0	14	19	0	2	5	0	0	0	0	0	1	0	0	2	0	0	23	0	7	5	0	0
Per cent of 156....	85	0	15	90	0	10	100	0	0	0	0	0	100	0	0	100	0	0	77	0	23	100	0	0

ROA is right occipito—anterior presentation; LOA is left occipito—anterior presentation; LSA is left sacrum—anterior presentation; LSP is left sacrum—posterior presentation; RSP is right sacrum—posterior presentation; RSA is right sacrum—anterior presentation; ROP is right occipito—posterior presentation; LOP is left occipito—posterior presentation.

A study of the basal metabolism of the mother during pregnancy as related to the handedness of the infant was made to investigate the hypothesis that if the prenatal environment were a determinant in preferential dextrality, the child of a mother with a tendency toward hyperthyroidism might show a tendency toward ambidexterity, whereas the child of a mother with a tendency toward hypothyroidism might be inclined to be either definitely right handed or definitely left handed. The theory back of this hypothesis was that the child would seem that the basal metabolism of the mother and the handedness of her child are not related.

Another prenatal factor to be investigated was that of birth weight. It was known that a big child would have a fixed position longer than a small one. This led to the hypothesis that smaller babies would have a greater tendency toward ambidexterity than larger ones. There were 145 cases in this study, of which 23 or 15.9 per cent were left handed and 122 or 84.1 per cent were right handed. No ambidextrous babies were reported.

Seven of the 23 left handed children had birth weights below the average of 3866 grams, that is, 30.4 per cent. Sixteen of the 23 left handed children had birth weights above the average, or that is 69.6 per cent. Seventy of the 122 right handed children had birth weights below the average, or, that is, 57.4 per cent. The number of right handed children above the average birth weight was found to be 52 or 42.6 per cent. This would indicate that there may be some relationship between low birth weight and type of dextrality, but it would seem that the 7 left handed cases below the average birth weight constitute too small a sample from which to draw conclusions regarding the 27.0 per cent difference between the percentage of left handed children below the average birth weight and the percentage of right handed children below the average birth weight. Further study of this hypothesis would, in the opinion of the author, lead to the conclusion that there is no relationship between birth weight and handedness. Table 2 presents the data concisely.

TABLE 2

A study of birth weight and handedness

NUMBER OF CASES		PERCENTAGES
23	L handed children in group	15.9
122	R handed children in group	84.1
7	L handed children below average birth weight	30.4
16	L handed children above average birth weight	69.6
70	R handed children below average birth weight	57.4
52	R handed children above average birth weight	42.6

Heredity as a prenatal factor was also investigated. It was believed that if heredity were a determining factor in handedness, the percentage of right handed children with an entire right handed heredity should be large, and the percentage of children with a mixed heredity should in the number of cases studied in this investigation follow a rather definite trend as to the extent of right and left handedness. Attention is especially called to the term "mixed heredity." There were no cases of pure left handed heredity reported. It should also be pointed out that only data on the handedness of the subjects and their parents were available.

The existence of left handedness in the blood line was checked in 330 cases. Of these 330 subjects, 178 or 53.9 per cent were found to be right handed with right handed heredity; 86 or 26 per cent were right handed with left handedness in the blood line; 16 or 4.9 per cent were left handed with a right handed heredity, and 50 or 15.2 per cent were left handed with a left handed heredity. Finally, 194 or, that is, 58.8 per cent had an entirely right handed heredity reported, and 41.2 per cent had an heredity in which there was some left handedness reported. The entire group was found to contain 79.9 per cent right handed-

ness and 20.1 per cent left handedness. It may be well to point out again at this juncture that a frequency curve for dextrality is impossible where the degrees of handedness are unknown.

The data on heredity must be taken to have indicative value only; since they were subjectively reported by individuals and were not objectively measured by a standardized dextrality test such as the tapping or grip test (5). However, for indicative purposes, this part of the study is worthwhile. Thus it is interesting to compare these results with those of the above mentioned study of the infants who were actually tested with the reaching test for forty trials. It was found in that total group of actually tested babies that 67 of the 137 were right handed babies, or that is 48.9 per cent, who came from a reported right handed blood line. Furthermore, 46 or 33.5 per cent of the right handed babies had left handedness reported in their family lines. Also, 14 left handed babies, or that is, 10.2 per cent had left handedness reported in their blood lines, and 10 left handed babies, or that is 7.4 per cent, had an entire right handed heredity reported. It was found that 56.3 per cent of the entire group had a right handed heredity reported, and 43.7 per cent of the group had some left handedness in the blood line reported. Further, the entire group was found to contain 82.4 per cent right handedness and 17.6 per cent left handedness. Table 3 illustrates well the agreement of the two studies. It should be remembered in studying these data that the 137 cases are included in the 330 cases. A second separate study was made for the 137 cases because they represent cases of actually tested infant handedness, and not merely reported infant handedness.

TABLE 3

A study of heredity and dextrality, 330 cases

SUBJECTS	RIGHT HEREDITY		LEFT HEREDITY		TOTALS
	number	*per cent*	*number*	*per cent*	*per cent*
Right handed	178	53.9	86	26.0	79.9
Left handed	16	4.9	50	15.2	20.1
Totals	194	58.8	136	41.2	100.0
Right handed	67	48.9	46	33.5	82.4
Left handed	10	7.4	14	10.2	17.6
Totals	77	56.3	60	43.7	100.0

It is interesting to note that 50 or 36.8 per cent of the 136 cases who had left handedness reported in the blood line were left handed as contrasted with 16 or 8.2 per cent who were left handed of the 194 cases who were reported to be of an entirely right handed heredity. It would seem, therefore, that there may be an hereditary element involved here. On the other hand, studies of other groups

indicate that extensive, careful experiments are necessary before definite conclusions can be drawn.

On the basis of the results obtained in this infant study it would seem that it is safe to conclude that:

1. There is no causal relationship between the dominant position of the foetus, the birth position of the child and dextrality.

2. The basal metabolism of the pregnant mother does not affect the dextrality of her child.

3. The birth weight of the infant at the time of delivery is not a determining factor in its dextrality.

4. The hereditary factor as indicated by the reported heredity is probably a significant quantity and a really scientific, objective measurement of this factor should be made.

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REFERENCES

(1) Cunningham, D. J.: Right handedness and left brainedness. Journal Anthropological Institute, **32**.

(2) Gould, G. M.: Right handedness and left handedness. Lippincott and Co., 1908.

(3) Moss, F. A.: Applications of psychology. Cambridge, Mass. 1929.

(4) van Biervliet, M.: L'asymetre sensorielle, Bulletins de l'Academie royale de Belgique, 3me serie, Tome **34**, Bruxelles, 1897.

(5) Woo, T. L., and Pearson, Karl: Dextrality and sinistrality of hand and eye. Biometrica, **19**.

The Order of Participation of Limbs in Responses to Tactual Stimulation of the Newborn Infant

LOUIS DELMAN[1]

INTRODUCTION

MANY previous investigators have maintained that the behavior of the newborn infant is unorganized, random and chaotic, although some fairly specific patterns of the order of simple reflexes, such as sneezing, plantar, palmar, sucking and swallowing responses are present at birth.

Irwin (5) conceives of the behavior of newborn infants as falling into two descriptive categories: specific movements and mass activity. A specific movement is defined as "a segmental activity which occurs at a rate slow enough that it can be discriminated by an observer." Mass activity "involves the entire organism and proceeds at a rate too rapid for analysis, and often with uninterrupted continuity." Specific movements involve a single bodily segment. Mass activity is organi mic or non-segmental in character. Specificity of behavior patterns in later life is held to be derived by a process of differentiation from an original matrix of mass activity.

Pratt, Nelson and Sun (9) hold similar views on the nature of the neonate organism.

> "Its behavior is generalized, that is stimulation of almost any group of receptors by almost any kind of stimulus will lead to a response in almost any part of the organism. The reaction tends, however, to mainfest itself most strongly in that part of the organism which is stimulated, and from there spreads out with decreasing frequency and intensity to the other segments of the body."

A second and older type of theory holds that the newborn is primarily a system of reflexes, whose behavior consists in a variety of specific, simple reflexes as well as some complicated specific responses of a reflexive nature such as instincts and basic emotions. The infant develops according to this view by modification and conditioning of these reflexive patterns. Such a view with reference to the development of emotional behavior is held by Watson (11).

This study is essentially an effort to analyze responses of the newborn with a view to determining the exact manner of their organization. The

[1] The writer wishes to acknowledge his indebtedness to Dr. Wayne Dennis, under whose direction this investigation was performed. Infants were made available for study through the kindness and coöperation of Dr. L. T. Royster of the University of Virginia Hospital.

earlier studies, dependent as they were upon unaided directed observation, could not attempt a detailed analysis.

If one could, in some manner, study the neonate's activity at a diminished rate, the relations involved in the movements of the various limbs could be examined and one might be able to substitute exact measurements of relations for the gross descriptive terms which now prevail.

For this purpose, the method of motion picture analysis obviously suggests itself as the best available method of preserving the responses for repeated analyses at a decreased rate of activity.

One inquiry into the regularity of responses is to ask whether or not they begin in a regular manner. This specific phase of the problem is the subject of the present research. This study is limited to analysis of the beginning of multisegmental, complicated responses. The only previous characterization which I was able to find in the literature, concerning the initiation of the total bodily response was made by Sherman (10).

> "The initial response, in other words, occurs in the part stimulated and spreads to other parts of the body. But the spread of these movements occurs so quickly that unless closely observed, they will appear only as generalized activity of the entire body, especially of the arms and legs."

Procedure

Motion pictures were taken in the University Hospital with a Cine Kodak Model B. K. A. camera (focal lens reading—1.9). The speed of running was approximately sixteen exposures per second. The camera was set in motion immediately preceding application of the stimulus and was shut off sometime after the response had involved two limbs or after ten seconds without a response had elapsed.

The apparatus was the same as that previously used by Gilmer (4). A wooden camera holder, each of whose 4 legs fitted over a corner of the infant's steel crib, was provided with a pointer to indicate the center of the photographic field. Illumination was provided by throwing the rays of a double Kodalite (Model B), which contained two 500 w., 115 v. Mazda lamps, against the wall directly over the subject's crib. The Kodalite was directed toward the wall at an angle which allowed no light to reach the infant directly from the lamp.

The stimulus was a flip of the experimenter's index finger. This was done by placing the nail of the index finger against the palmar surface of the thumb and exerting sufficient pressure to force the thumb outward and release the index finger, which then struck the subject. This procedure resulted, obviously, in variation of the intensity of the stimuli. Such variation makes any consistency in results even more significant than it would be if obtained when the intensity were kept constant. As a further experiment it would be interesting to control and systematically vary the stimulus intensity. However, one may urge that a first study may legitimately be concerned with the effects of stimuli of a practical rather than of an ideal nature.

The stimuli were applied to 4 regions of the body, namely to the sole of a

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foot and the palm of a hand on both left and right sides of the body. In some cases the palm of the hand could not be reached without moving the infant's arm. In such situations, the back of the hand or the wrist was stimulated. Foot and arm stimulations were applied alternately. Right and left sides of the body were stimulated alternately from day to day. For example; on March 2 stimulus #1 was applied to the left foot, #2 to the left hand, #3 to the left foot, etc. On the next day stimulus #1 was applied to the right foot, #2 to the right hand, #3 to the right foot, etc.

There were two experimental periods each day, beginning in every case about one hour after a nursing period and ending about seventy-five minutes later. (The infants were nursed at 2 A.M., 6 A.M., 10 A.M., 2 P.M., 6 P.M., and 10 P.M.) Most of the experimental periods were at 7 A.M. and 3 P.M. One hour after nursing was selected as the most likely time to find the infants asleep. All data used in this experiment were taken when the infants were asleep, the criteria of sleep being closure of the eyes and immobility.

Uncovering the baby, which was always done immediately after setting up the photographic apparatus and before stimulation was begun, always resulted in a response. In this case, as in all others, where there was previous movement, an interval of at least ten seconds of immobility was allowed to elapse before any further stimulus was applied.

Control pictures during which there was no experimental stimulation were taken at various intervals during each experimental period. These were taken under the same conditions as were the experimental pictures, the only difference being lack of the finger flip.

The experimenter, who was generally alone in the nursery during experimentation, performed all the tasks, operating the camera with the left hand, applying the stimuli with the right hand and taking notes between stimulations.

The pictures were later analyzed to determine the first and second limbs to enter into the response. These will be designated hereafter as the first, or initial response and the second response. The films were projected on a white cardboard screen by a Kodascope (Business Model) Projector, which was run by hand. In most cases, by turning the projector crank very slowly, it was possible to determine with assurance the order in which the various limbs entered into the response. In many cases, however, determination by this method was impossible. In these cases, markers were fastened to the screen, which showed a still picture of the infant at the moment of application of the stimulus. One edge of each of the markers was placed in contiguity with the outline of each limb concerning which there was uncertainty at the point at which the first component of movement was evident. The projector was then cranked, frame by frame, until one of the limbs was no longer contiguous with its mark. This method proved highly successful in obtaining temporal differences where they ex-

isted. If this method yielded no temporal difference, the limbs in question were said to have begun moving simultaneously. Absolute reaction times were not calculated for the reason that they are not essential to the problem and that calculating reaction time from motion pictures is subject to obvious inaccuracies.

A number of cases had to be omitted from the computations due to lack of response or to simultaneity of response. Since there was obtained in many cases a definite first response and no second response or a simultaneous second response of two or three limbs, the number of second responses in the tabulations is less than the number of first responses. These cases of lack of or simultaneity of response both in first and second responses and in second responses only, were too few to merit further study, although with a large number of such cases analysis might provide some interesting results.

Subjects. The subjects of this study were three negro infants. Negro subjects were chosen because of better provision for experimentation which exists in the negro, rather than the white, nursery of the University Hospital. Baby S, a healthy, normal, male infant was studied from the fourth through the eleventh day of life. A total of 146 pictures of this subject were taken. Seventeen were control pictures. Seventeen were omitted from the computations due to simultaneity of response or lack of response.

Baby M, a healthy, normally delivered, female infant was studied from the second through the twelfth day. A total of 335 pictures were taken. Fifty-four were control pictures and fifty-two were omitted due to simultaneity or lack of response.

Baby D was a female infant delivered by Caeserian section. She was less active than the other two subjects, consequently a greater percentage of her pictures showed no response. A total of 237 pictures were taken. Thirty-five were control pictures and 71 were omitted due to lack of or simultaneity of response.

RESULTS

Control Pictures. The control pictures show that very little movement occurs, under the conditions of this experiment, when the stimulus is not applied. Seventeen control pictures of Baby S were taken. Of these, 88 per cent showed no movement. Of the 54 control pictures of Baby M, 80 per cent showed no movement. Baby D's records show no movement in 88½ per cent of the control pictures, which were 35 in number. The movements which occurred during the control pictures were too few to merit further analysis.

Number of Responses Involving All Limbs. Seventy-seven per cent of the responses of Baby S, 73 per cent of Baby M's and 46 per cent of Baby D's responses (those which were used in the following results) involved all four limbs. It must be remembered in this connection, that the camera was stopped in some cases before movement had ceased so that, had the entire course of reaction been photographed, a still larger percentage of responses would have shown move-

ments of all the extremities. It is obvious then that the responses which are to be analyzed are, for the most part, multi-segmental reactions.

The Initial Response. (1) Relation to the Stimulated Limb. According to the quotation from Sherman (10), above cited, the generalized response to almost any type of intense stimulus is supposed to begin in the stimulated limb and then spread to the other limbs.

These data indicate that, on the average, the first response is more likely to occur in the stimulated member (in about one third of the cases) than in any other particular member. However, it occurs with greater frequency at some part other than the stimulated member.

The method of analysis was to characterize the limb which moved first with respect to its direction from the stimulated member. These characterizations were four, namely "Same," "Contralateral," "Diagonal" and "Homolateral." For example, when the right foot is stimulated, an initial movement of the right leg is called "Same;" of the left leg, "Contralateral;" of the left arm, "Diagonal;" of the right arm, "Homolateral." The results of this analysis are given in table 1.

Table 1, in which the data are arranged to show differences between subjects, indicates the percentages of initial responses of each of the four types; same as, contralateral to, diagonal to, or homolateral to the stimulated limb. The first, second and third columns show the percentages obtained in foot stimulations for babies M, S and D respectively. The fourth column represents the critical ratios of the largest differences between any two of the subjects in a given type of initial response. The fifth column represents combination of the corresponding data for all three subjects. The other columns represent, as indicated, the corresponding data for arm stimulations and for combination of both foot and arm stimulations.

The reliabilities of the differences between the percentages for foot and for arm stimuli in the same individual are next considered. This comparison

TABLE 1

Percentage of each type of initial response
Reliability of individual differences

	FOOT STIMULATIONS					ARM STIMULATIONS					SUM OF FOOT AND ARM STIMULATIONS				
	Baby M	Baby S	Baby D	$\frac{D}{\text{Sigma } D}$	Sum of 3 Subjects	Baby M	Baby S	Baby D	$\frac{D}{\text{Sigma } D}$	Sum of 3 Subjects	Baby M	Baby S	Baby D	$\frac{D}{\text{Sigma } D}$	Sum of 3 Subjects
Numer of Cases.....	121	53	70		244	108	59	61		228	229	112	131		472
"Same".....	34%	30%	48%	1.9	37%	31%	41%	21%	2.4	31%	33%	36%	36%	0.6	35%
"Diagonal".....	25%	36%	9%	3.6	23%	30%	24%	36%	1.5	30%	27%	29%	21%	1.4	26%
"Contralateral"....	35%	19%	36%	2.0	30%	24%	23%	15%	1.5	21%	29%	21%	26%	1.7	25%
"Homolateral".....	8%	15%	7%	1.4	10%	15%	12%	28%	2.2	18%	11%	14%	17%	1.5	14%

is shown in table 2, which consists in a rearrangement of the same data as in table 1 for purposes of comparing the results of foot and arm stimuli rather than the results of different subjects for one type of stimulus. The differences are quite low in reliability for two of the subjects and highly reliable for the third. When the data for all three subjects are combined, the differences become smaller and of little reliability.

initial response to the stimulated limb: The initial response occurs in the stimulated member in about one third, the diagonal limb in one fourth, the contralateral limb in one fourth and the homolateral limb in one sixth of the cases. Individual differences are very frequent and sometimes very large. In many cases these individual differences would obscure relationships if the responses of all subjects were added together without consider-

TABLE 2

Percentage of each type of initial response
Reliability of differences between foot and arm stimulation

	BABY M			BABY S			BABY D			SUM OF 3 SUBJECTS		
	Foot Stimulations	Arm Stimulations	$\frac{D}{\text{Sigma D}}$	Foot Stimulations	Arm Stimulations	$\frac{D}{\text{Sigma D}}$	Foot Stimulations	Arm Stimulations	$\frac{D}{\text{Sigma D}}$	Foot Stimulations	Arm Stimulations	$\frac{D}{\text{Sigma D}}$
Number of Cases	121	108		53	59		70	61		244	228	
"Same"	34%	31%	0.5	30%	41%	1.2	48%	21%	3.4	37%	31%	1.4
"Diagonal"	25%	30%	0.9	36%	24%	1.4	9%	36%	3.8	23%	30%	1.7
"Contralateral"	35%	24%	1.8	19%	23%	0.5	36%	15%	3.0	30%	21%	2.25
"Homolateral"	8%	15%	2.2	15%	12%	0.5	7%	28%	3.3	10%	18%	2.5

Table 3 shows the reliability of the differences $\frac{D}{(\text{Sigma D})}$ between the different types of initial response. The percentages used are those in the extreme right hand column of table 1 which represents the percentages of the total number of initial responses to both types of stimuli of all three subjects. The critical ratios show that all the differences are reliable except that between "Diagonal" and "Contralateral" which is only 1 per cent.

Having examined the differences, we can make the following general statement regarding the relation of the

ing the subjects separately. This is due to a frequently occurring compensatory relation between subjects. It is urged that the importance of determining the behavior organization of the *individual* be not overlooked by those who may undertake studies upon a larger number of infants. While the present study does not determine how *common* are the facts which were found, it may be indicated that the application of fewer stimulations per subject to a larger number of infants would not have shown how the behavior of *any* infant was organized.

(2) Laterality. One aspect of be-

havior which has been frequently investigated is laterality, by which is generally meant any difference in functioning between the two sides of the body. A number of theories have been postulated to explain laterality differences. There are theories which account for handedness on the physical basis of cortical or other anatomical asymmetry. An example of such a hypothesis is that of Jordan (6), who holds that handedness is determined by cerebral asymmetry, which in turn is due to differential blood supply to the cerebral hemispheres during fetal life. On the other hand, there are empiricists who maintain that laterality is due entirely to training and social influence. Both of these schools of thought seem either to imply or definitely state that laterality is a general phenomenon in individuals, *i.e.*, is the same for all acts and situations. An obvious alternative, which seems to have been appreciated extremely rarely in the literature, is that laterality is specific to the different types of behavior. This would imply probably, though not necessarily, an empiristic rather than a nativistic view of the origin of laterality.

TABLE 3

Reliability of differences between each type of initial response—combined data for three subjects

	SAME	DIAGONAL	CONTRALATERAL	HOMOLATERAL
"Same"				
"Diagonal"	3.1			
"Contralateral"	3.4	0.3		
"Homolateral"	7.8	4.8	4.4	

If laterality is at all native, it is most reasonable to believe that the expression of its native component is general for all types of laterality. If there is ever a generalized laterality it would seem that the newborn infant is the most likely individual to exhibit it. Thus any laterality in first responses exhibited by the subjects of this experiment, would represent a contribution to the complete analysis of behavior of the newborn with respect to the problem of generality or specificity of lateral dominance.

Table 4 shows for all 3 subjects the percentage of initial responses which were on the right side (*i.e.*—right leg or right arm) and on the left side. The calculations are given separately for stimulations of the left side and the right side, then all stimulations combined. The reliability of each difference between percentages of right and left initial responses is given. From inspection of the table it is evident that the differences are small and of low reliability. The probability that these infants are not ambidexterous is not very high, for in children a few years older one generally obtains 70 per cent or more of one-sidedness. No right: left ratio in table 4 is greater than 60:40. In short, these data do not show any pronounced asymmetry in behavior.

(3) Cephalo-Caudal Differences. Table 5 shows for each subject the percentage of leg initial responses as compared with arm initial responses, and the reliability of the differences obtained. In general, when the data for foot and arm stimulations are

combined the only reliable differences are in favor of leg initial responses. This is not due to any possible influence of the greater number of foot stimulations because the data for foot and arm stimulations were averaged so as to make their effect equal in the total percentage.

stimulation, than leg initial responses to foot stimulation. This is the case only for Subject S whose differences are of lowest reliability. The other two infants, whose differences are more reliable show the opposite tendency, presumably greater specificity when the feet are stimulated.

TABLE 4

Laterality

	BABY M				BABY S				BABY D			
	Number of Cases	Right Initial Response	Left Initial Response	$\frac{D}{\text{Sigma } D}$	Number of Cases	Right Initial Response	Left Initial Response	$\frac{D}{\text{Sigma } D}$	Number of Cases	Right Initial Response	Left Initial Response	$\frac{D}{\text{Sigma } D}$
Right Side Stimulated	109	47%	53%	0.9	64	47%	53%	0.7	80	57%	43%	1.8
Left Side Stimulated	120	60%	40%	3.2	48	46%	54%	0.8	51	58%	42%	1.6
Sum of Right and Left Stimulated	229	54%	46%	1.7	112	46%	54%	1.2	131	58%	42%	2.6

TABLE 5

Cephalo-caudal differences

	BABY M				BABY S				BABY D			
	Number of Cases	Per cent of Foot Initial Responses	Per cent of Arm Initial Responses	$\frac{D}{\text{Sigma } D}$	Number of Cases	Per cent of Foot Initial Responses	Per cent of Arm Initial Responses	$\frac{D}{\text{Sigma } D}$	Number of Cases	Per cent of Foot Initial Responses	Per cent of Arm Initial Responses	$\frac{D}{\text{Sigma } D}$
Foot Stimulations	121	69%	31%	6.3	53	49%	51%	0.1	70	84%	16%	11.0
Arm Stimulations	108	45%	55%	1.5	59	36%	64%	3.2	61	64%	36%	3.1
Foot & Arm Stimulations	229	57%	43%	3.5	112	43%	57%	2.1	131	74%	26%	8.6

If the cephalo-caudal developmental gradient is in operation in the neonate one might expect these data to be affected in one or both of two ways. First, assuming that specificity of initial response is an index of level of development, then there should be more arm initial responses to arm

Secondly, greater level of development in the anterior part of the body may be indicated by a greater number of arm initial responses than leg initial responses regardless of the stimulus. As pointed out above, this also is not the case. The reliable differences favor leg initial responses.

The Second Response. The second limb to enter into the response was characterized in two ways, namely its relation (Same, Contralateral, Homolateral, Diagonal) to the stimulated limb and its relation to the first limb to respond (Diagonal, Contralateral, Homolateral).

Table 6 shows the relation of the second responding limb to the stimulated limb as well as the relation of the first to the stimulated limb. For example the first column shows that in 33 per cent of the cases the first limb to respond was the stimulated limb. The second column shows that in 17 per cent of the cases the stimulated limb responded second. Adding these two values we get the 50 per cent in the third column, which means that the stimulated limb responded either first or second in 50 per cent of the cases. Further, in 18 per cent of the cases, for Baby M, where a first response was recorded, there was no second response or else two limbs moved simultaneously after the first. Thus there are 187 second responses for subject M, 89 for S and 96 for D.

In general one may conclude from table 6 that the second response occurs about equally often in the limbs diagonal to, contralateral to, homolateral to and same as the stimulated member. Also, the stimulated member, the diagonal and contralateral respond either first or second in from 37 to 55 per cent of the cases, and the homolateral responds either first or second in 32 to 34 per cent of the cases. Thus there is a tendency for the homolateral limb to enter into the response later than the other limbs or not at all.

The data concerning the relation of the second responding limb to the first responding limb are given in table 7. It is evident that about half of the second responses are contralateral to the first responding limb, while about one fourth are diagonal and one fourth homolateral. This indicates a pronounced tendency for arm and arm, and leg and leg to react together in time, for there are two arm-leg combinations possible to one arm-arm or leg-leg combination.

TABLE 6

The second response
Relation to the stimulated limb

	BABY M—229 CASES			BABY S—112 CASES			BABY D—131 CASES		
	Second Response	First Response	Moved First or Second	Second Response	First Response	Moved First or Second	Second Response	First Response	Moved First or Second
"Same"	17%	33%	50%	14%	36%	50%	19%	36%	55%
"Diagonal"	23%	27%	50%	17%	29%	46%	16%	21%	37%
"Contralateral"	19%	29%	48%	30%	21%	51%	14%	26%	40%
"Homolateral"	23%	11%	34%	18%	14%	32%	16%	17%	33%
No Second Response	18%			21%			35%		

DISCUSSION

A survey of the literature dealing with the behavior of the newborn reveals a great deal of immediate observational data with characterizations of behavior patterns which are of necessity couched in relatively gross

description. Seldom in the literature has an attempt been made to characterize, in responses of the type obtained in this study, the details of relations between the various components of the responses.

The responses observed in this study are in agreement with the observations of Coghill (1); Pratt (7); Pratt, Nelson and Sun (9); and Irwin (5), that the responses of the neonate to intense stimuli are generalized, that is involving the greater part of the organism. In two of the subjects 73 per cent and 77 per cent of the responses, as much of them as was recorded by the camera involved movement of all four limbs. In the third subject only 46 per cent of the responses involved all four limbs. In general the only responses which could not be characterized as involving the greater part of organism were those resulting from especially weak stimuli.

TABLE 7

Relation of second response to first response

	BABY M	BABY S	BABY D
"Diagonal"	23%	31%	20%
"Contralateral"	49%	44%	61%
"Homolateral"	27%	25%	19%
Number of Cases	187	89	96

Pratt (7); Pratt, Nelson and Sun (9); and Irwin (5) do not stop at describing neonate responses as generalized, but go further to characterize them as random, chaotic and unorganized.[2] However, Coghill (1), whose findings have been applied to neonate behavior by Irwin (5), has maintained, as Dennis (2) indicates, that the responses are not only generalized but also patterned. He speaks of behavior patterns developing by expansion and individuation from a total, integrated pattern. But he does not deny that there may be more than one such total pattern, from which later patterns develop, in the behavior of the newborn. There may be a number of total patterns, each specific to a definite range of stimuli under a definite set of conditions (3).

In this study an attempt was made, by analyzing the time relations involved between the various component of the responses, to contribute toward a finer detail in the characterization of infant responses. Characterization of the neonate as behaving in a random manner implies a sedative finality which tends to halt analysis at the surface. It must be kept in mind that chance or randomness is nothing but a scientific construct, by which one characterizes phenomena which have not been successfully correlated with external conditions. The word random is an expression of the scientist's lack of knowledge of relationship. The aim of science is to substitute correlation for randomness.

The results of this study indicate that the responses do not occur in a chance fashion. Considering the large number of factors which remained uncontrolled, it seems highly probable that further control would yield greater constancy in responses, and thus further knowledge of correlation between conditions and behavior.

The next step indicated, therefore, would be to control factors, which were not controlled in this study, some

[2] In a series of further publications Pratt has presented data which tend to modify his earlier views (8).

of which have never to my knowledge, been controlled. Systematic control and variation of such factors as head position, flexion or extension of the limbs before stimulation, intensity of stimuli, together with further detail in analysis of behavior should establish fairly definite correlations between the behavior and the external conditions.

SUMMARY

This investigation was undertaken to characterize in one detail the gross bodily responses of newborn infants. That detail is the order of participation of the different limbs in the gross response. The subjects were stimulated by finger flips on a hand or foot alternately. Their responses were recorded by a motion picture camera and analyzed to find the first and second limbs to enter into each response.

The results show that in general the initial response occurs in the stimulated limb in about one third of the cases, in the homolateral limb in about one sixth, and in the contralateral and diagonal limbs in about one fourth of the cases each. More first responses occur in the legs than in the arms. There is no lateral dominance in the first response.

The second response appears to be unrelated to the place of stimulation but half of the second responses are contralateral to the first responding limb. The other half are equally divided between the extremities which are homolateral and diagonal to the first responding limb. This indicates a tendency for leg and leg or arm and arm rather than an arm-leg combination to react together in time. Thus the limbs which are most frequently the third and fourth to respond must lie at the opposite end of the body from the locus of the first and second movements.

In general these results have shown that although the responses are generalized, there is some patterning. The bearing of this upon theoretical considerations of neonatal behavior has been indicated.

REFERENCES

(1) COGHILL, G. E.: The early development of behavior in amblystoma and and in man. Arch. Neurol. and Psychiat., 1929, **21**, 989–1009.

(2) DENNIS, W.: The rôle of mass activity in the development of infant behavior. Psychol. Rev., 1932, **39**, 593–595.

(3) DENNIS, W.: A description and classification of the responses of the newborn infant. Psychol. Bull., 1934, **31**, 5–22.

(4) GILMER, B. v. H.: An analysis of the spontaneous responses of the newborn infant. J. Genet. Psychol., 1933, **62**, 392–405.

(5) IRWIN, O. C.: The amount and nature of activities of newborn infants under constant external stimulating conditions during the first ten days of life. Genet. Psychol. Monog., 1930, **8**, 1–92.

(6) JORDAN, H. E.: The crime against left-handedness. Good Health, 1922, **57**, 378–383.

(7) PRATT, K. C.: The neonate, in a handbook of child psychology, 2nd ed., rev., Worcester, Mass., Clark U. Press, 1933, 163–208.

(8) PRATT, K. C.: Generalization and specificity of the plantar response in newborn infants. The reflexogenous

zone: I. Differential sensitivity and effector-segment participation according to the area of stimulation. J. Genet. Psychol., 1934, **44**, 265–300.

(8) PRATT, K. C.: Generalization and specificity of the plantar response in newborn infants. The reflexogenous zone: II. Segmental patterning of responses. J. Genet. Psychol., 1934, **45**, 22–38.

PRATT, K. C.: Generalization and specificity of the plantar response in newborn infants. The reflexogenous zone: III. The effects of the physiological state upon sensitivity, segmental participation and segmental patterning. J. Genet. Psychol., 1934, **45**, 371–389.

(9) PRATT, K. C., NELSON, A. K., and SUN, K. H.: The behavior of the newborn infant. Ohio State Univ. Stud.: Contrib. Psychol., 1930, No. 10, pp. ix and 237.

(10) SHERMAN, M., and SHERMAN, I. C.: The process of human behavior. New York: Norton, 1929, pp. 227.

(11) WATSON, J. B.: Behaviorism. 2nd ed., rev., New York: Norton, 1930, pp. xi and 308.

The Latent Memory Span of the Preschool Child[1]

HELENA MALLAY

KOFFKA, in his "Growth of the Mind," states that there are two stages in learning, the 'problem of achievement' and the 'problem of memory' and that although the problem of achievement may be solved by trial and error, instinct, training, or insight, it is the problem of memory which is most closely bound up with learning. Without reservations, Koffka asserts that 'all learning depends on memory.'

The experiment described here was set up in an attempt to investigate functioning memory, *i.e.* the latent memory span at the preschool age levels and to study the interrelationships of the problems of 'achievement' and 'memory' in the ordinary learning situation (devoid of unusual emotional tones) which the preschool child meets. Can an average latent memory span be determined for preschool children? What changes are there with age? To what extent is the latent memory span dependent on the method by which 'achievement' takes place? How much is it influenced by the emotional personality characteristics of the individual?

The problem set was to ascertain the latent memory span of the preschool child as shown in the recall of certain movements necessary for the opening of boxes. Testing memory by the recall of a series of motor responses controlled the verbal factor which is so variable at the preschool level and unduly complicates a study of memory. Latent memory spans in a variety of situations were studied and compared. Intensive analysis was undertaken of the effect on the resultant latent memory span when the simple problem of the recall of one movement was complicated by adding to it a second and third movement and when changes were made in the method by which 'achievement' took place. Discussion was directed toward the comparison of the changes in latent memory spans when the problem of memory was complicated by increasing the number of movements and by changing the method of achievement. The latent memory spans for the opening of boxes served as the constant factor in each situation. The high intercorrelations found between situations described below made tenable such comparison of results.

Subjects. The subjects were 18

[1] A report of a study presented in partial fulfillment of the requirements for the degree of Master of Arts, Department of Child Study, Vassar College. This study was carried through under the direction of Martha May Reynolds, Professor of Child Study.

children enrolled in the Vassar College Nursery School during the year 1932–1933. Table 1 gives the mean and the range of chronological ages, mental ages, and intelligence quotients of the age groups studied.

Materials. The materials consisted of three series of boxes—Types A, B, and C, described below. Type A box was one requiring for its successful opening one movement carried out in either the horizontal or vertical direction; Type B required two movements, one of which had to be carried through before the other; Type C required three movements to be carried through in a definite order. Boxes were found which were unusual, those which the subjects would not have encountered in their daily experiences.[2] The boxes all contained a small object within which served as a stimulus for opening—a car, a ring, a pencil, a ball, etc. The total number of boxes used will be given and explained in the discussion of the procedure.

Definitions. The latent memory span was defined as the longest time interval over which memory functions overtly, *i.e.* the upper time limit of the interval beginning with the first presentation of the object to the time of recall and recognition. Failure meant an evident absence of the immediate and direct pursuit of the movements necessary for the opening of the box. If the subject failed after a given interval, repetitions were made for shorter intervals until the time of the first success. If the subject succeeded, repetitions were made for longer intervals until the time of the first failure.

A *demonstration* referred to a single opening and closing by E of a single box. A *sitting* referred to the period varying from two to five minutes beginning with the subject's entrance into the examining room and continuing until the time he left to return to his play. This may have included

TABLE 1

Chronological ages, mental ages, and intelligence quotients of age groups studied

	2 YEARS OLD	3 YEARS OLD	4 YEARS OLD
Number of cases	6	8	4
Mean C.A.	2–5*	3–5	4–2
Range	2–3 to 2–8	3–1 to 3–10	4–1 to 4–3
Mean M.A.	2–9	4–1	5–1
Range	2–6 to 3–0	3–7 to 4–10	4–6 to 5–6
Mean I.Q.	114	118	123
Range	108 to 127	106 to 132	106 to 131

* 2–5 signifies 2 years and 5 months.

[2] At seven different times, E presented a new box to a subject—in all cases an older child—and in not one case was the subject able to open the box immediately without a definite period of trial and error.

more than one demonstration. The number of sittings varied with the individual subject and depended on the number of repetitions necessary to determine the latent memory span.

An *experiment* referred to a method of initial presentation carried through on all three types of boxes. Four different methods of 'achievement' were used: demonstration with visual and auditory directions, demonstration with only visual directions, trial and error and relearning, and trial and error without relearning. A *situation* referred to the further differentiation of the parts of the experiments, *i.e.* situation IA referred to Experiment I on type A box; situation IB referred to Experiment I on type B box, situation IIA referred to Experiment II on type A box, etc.

Procedure. The general procedure which remained relatively constant throughout the entire research will be given in detail for the first situation. Each of the other situations will then be discussed noting in each case only the variations from the first.

Situation IA: The subject was taken to the examining room by E. When S was seated at the table, E presented a Type A box. E shook the box and said, "There's something in here to play with. See how I open it" and showed the subject how to open the box, accompanying her movements with verbal directions, *e.g.* "we push here" or "lift this" or "pull this off." E allowed S to remove the contents—a ring, a toy auto, or a pencil—and to play with them for a few seconds. (If S made no attempt to get the object, E took it out and gave it to him.) The object was then replaced in the box, usually by S; the box was quickly closed by E and handed back to the child for the reopening. E noted whether or not S could open it immediately and directly without any false movements. *If he did,* he was allowed to play with the contents again for a few seconds, following which the box was replaced on the table and S left the examining room. *If S did not* open it correctly following demonstration, the box was removed from him (trial and error opening was not allowed) and the demonstrations were repeated, as described above, until the subject opened the box immediately and correctly when it was presented to him. The number of demonstrations required was noted.

After an interval of about twenty-four hours, S was brought back to the examining room. The box offered at the preceding sitting was re-presented. E said, "There's something here for you to play with. Do you remember this box?" The box was handed to S and E noted whether he opened it immediately and correctly. If not, E recorded a failure. An immediate success was scored a plus. Then, as this box was removed, E presented another Type A box, *i.e.* one requiring the "one" movement for its opening but which was different from the first Type A box in color, shape, and object which it contained. The procedure of the first sitting was repeated, *viz.*, E shook the box and said, "There's something else in here that's nice to play with. See how I open it." E opened it, accompanying her demonstration with verbal directions. S was allowed to play with the object inside for a few seconds after which it was replaced in the box. E closed the box and then presented it for the reopening by S. E noted whether he opened it immediately and correctly. As at the first sitting, if an incorrect start was made, the box was immediately removed and demonstrations were repeated until the box was opened directly and correctly after the presentation. Only when this was accomplished was S allowed to play with the contents. This concluded the second sitting. The number of demonstrations needed for the second box was noted as were any verbal comments made by S.

If, in this latest test for memory, S succeeded in opening the box, the test for the second Type A box took place after a longer interval, *e.g.* two or three days. If S failed

to recall the necessary movement for the opening, the next test for recall took place after a shorter interval.

This procedure of test and re-presentation of a similar problem was continued until the latent memory span was determined for the one movement. This part of the experiment, Situation IA, was then concluded.

The average number of sittings with each subject for Situation IA was 7.0. The range extended from 4 to 11. The different Type A boxes were always presented in the same order so that at the second sitting, Type A box No. 1 was presented for recall and Type A box No. 2 as the new stimulus. At the third sitting, Type A box No. 2 was presented for recall and Type A box No. 3 as the new stimulus. The upper limit of the range showed the total number of Type A boxes used in Situation IA.

Situation IB: In this situation, Type B box replaced Type A box. The details of the procedure were exactly like those in Situation IA.

The average number of sittings with each subject was 7.6; the range, 5–11.

Situation IC: In this situation, Type C box was used. The details of the procedure were exactly like those in Situation IA.

The average number of sittings was 5.4; the range, 3–10.

Situation IIA: In this situation a Type A box was again used, one requiring a single movement for its successful opening, *not*, however, the same boxes used in *IA*. Except that the demonstration was *not* accompanied by verbal direction, the initial procedure in the demonstration of the opening of boxes was identical to that in Experiment I.

The average number of sittings was 4.8; the range, 3–7.

Situation IIB: Type B box replaced Type A box. The details of the procedure were exactly like those in Situation IIA.

The average number of sittings was 4.8; the range, 3–9.

Situation IIC: Type C box was used; the procedure remained exactly the same as in Situation IIA.

The average number of sittings was 3.4; the range, 3–8.

Situation IIIA: In Situation IIIA, trial and error on the part of the subject was substituted for the demonstrations by E. S, when seated, was given a Type A box, one he had not seen before. E shook it as she handed it to him and said: "There's something in here for you to play with. See if you can get it. Open the box." *No demonstration was given.* Time was taken with a stop watch from the moment the subject touched the box with the intention of opening it to the moment he had completed the last movement and the box was open. He was allowed to remove the contents and to play with them. The contents and the box were then removed by E. Replacing the contents, E closed the box, and returned it to S for a second opening through trial and error or insight. Again no demonstration was given. Time was again taken with a stop watch. After playing with the contents for a few seconds, S returned the box and contents which were put away by E. Any comments were noted. The test for memory and the presentation of a second Type A box at the second sitting proceeded as in Experiments I and II. With each new box, trial and error opening followed by a second trial and error opening was used in place of demonstrations.

The average number of sittings was 4.7; the range, 3–8.

Situation IIIB: Type B box replaced Type A; the procedure remaining the same as that in IIIA.

The average number of sittings was 4.7; the range 3–7.

Situation IIIC: Type C box was used; the procedure as in IIIA.

The average number of sittings was 5.2; the range 3–7.

Situation IVA: Trial and error learning without relearning was used here as the method by which "achievement" took place. Following, the first complete opening, arrived at through trial and error and perhaps insight, and following a few seconds of playing with the contents, the subject returned the box to E who removed it. It was not re-presented for a reopening. The sitting ended here.

The average number of sittings was 4.4; the range, 3–7.

Situation IVB: Type B box replaced Type A box; the procedure continued as in IVA.

The average number of sittings was 5.1; the range, 3–7.

Situation IVC: Type C box was used; the procedure as in IVA.

The average number of sittings was 4.3; the range 2–7.

To recapitulate. Research had been set up to determine the latent memory spans for the recall of movements necessary in the successful opening of boxes. Comparison of results on 3 types of boxes showed the effect of increasing the difficulty of the problem on the resultant latent memory span. Variations in the problem of 'achievement,' *i.e.* demonstration, with and without verbal directions, trial and error in place of demonstration, trial and error opening, with and without relearning, were carried through to study the subsequent effects on the latent memory span. Data on personality characteristics and methods of work were kept to see the effect of atypical reactions in this field on latent memory spans and learning.

Data. The latent memory spans in terms of days for each of the twelve situations were the major part of the data. General observation and test scores of personality characteristics were used to divide the subjects into two groups—those showing fairly usual and those showing very unusual personality traits in the matter of suggestibility and amount of initiative when left undirected in a situation.

Results. Table 2 gives the average latent memory span in days for each of the twelve situations.

TABLE 2

Latent memory span for the various situations

Intervals in days

	2 YEARS OLD			3 YEARS OLD			4 YEARS OLD		
	A	B	C	A	B	C	A	B	C
Expt. I[a]	8.4	3.3	2.0	12.0	6.0	5.4	13.5	6.0	7.0
Expt. II[b]	5.8	1.8	2.0	15.1	7.7	6.1	19.8	6.3	11.7
Expt. III[c]	5.9	2.1	1.5	12.9	10.9	4.4	11.7	9.0	4.0
Expt. IV[d]	3.3	0.6	0.3	9.5	4.4	1.6	7.5	5.5	2.9

[a] Auditory and visual demonstration.

[b] Visual demonstration only.

[c] Trial and error and relearning.

[d] Trial and error—*no* relearning.

Averages per age group showed that the latent memory span in days for all boxes seemed to increase with age. The increases showed the negative acceleration frequently found in growth curves and attributed primarily to maturation. However, questions arose at this point, namely: "Could one give approximately one week as an absolute standard latent memory span over which interval a two-year old would recall movements necessary to the opening of a box?" Did not the number of movements

and the method by which 'achievement' was accomplished change the length of time over which successful recall would occur? Did not the individual personality characteristics and methods of work affect the results?

Results for Types A, B, and C boxes showed that adding to the number of movements to be recalled shortened the latent memory span; a greater decrease being found when one movement was added to a problem involving only one movement than when added to a problem involving two movements. Results in the various Experiments showed that changing the method of initial presentation resulted in a changed latent memory span; 'achievement' by trial and error producing generally shorter latent memory spans than 'achievement' by demonstration.

What then seemed to be the factors in memory and learning? There was a general tendency for an increase in latent memory spans with age and a decrease with the greater complexity of the problem. Yet inconsistent results, as shown by the entanglements of the curves (fig. 1), indicated that there was more present in resultant learning than the one item—maturation of a single function, memory. If functioning memory, the latent memory span, were wholly or predominantly dependent on maturation, it would be expected that (a) the negatively accelerated curve would be found with each type of box; (b) the more complicated boxes would lag correspondingly behind the simpler ones at proportional amounts; (c) the more complicated experiments would lag correspondingly behind the simpler ones; and (d) individual curves would follow those designated as the probable ones for the group.

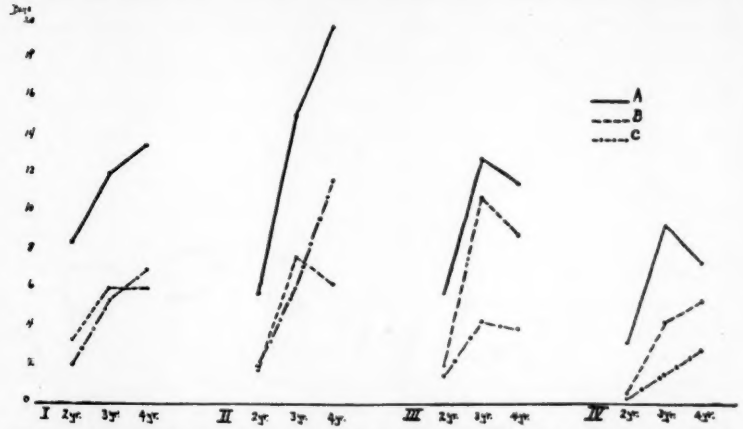

FIG. 1. LATENT MEMORY SPAN IN DAYS FOR AGE GROUPS TWO, THREE AND FOUR YEARS FOR DIFFERENT TYPES OF BOXES
The Roman numerals indicate the different experiments from I to IV

The actual graphs did not display

with any too great consistency the tendencies indicated above. An intensive analysis was undertaken of the variations in latent memory span with the different type boxes and with the different methods of presentation to see what might account for the disparity between the theoretical and the actual results. It was true that the number of cases were few. This fact might have been used to account for the results found. But analysis seemed to show that there was more involved than simply statistics and that a quantitative accumulation of subjects would not necessarily change and smooth out the curves.

In the analysis of the data gathered in Experiments I and II, it was found that the precise effect of the omission of verbal directions on latent memory spans could not be discovered in this study. Procedure called for unlimited demonstrations until S opened the box immediately following the demonstration. The number of demonstrations was always greater in II; the latent memory span was longer in II with the three- and four-year olds though not with the two-year olds. It would seem that even though S had not grasped the procedure sufficiently well to repeat the movements after the first or even second and third demonstrations, some learning might have taken place below the threshold of consciousness and acted in reinforcing the final demonstration. With two-year olds, in spite of the increase in the number of demonstrations, the latent memory span did *not* increase. Two-year olds tended to repeat verbal directions and their latent memory spans were appreciably higher when these were included in spite of additional demonstrations.

In Experiments III and IV, the box was handed to the subject to be opened through trial and error methods. In some cases, insight occurred. In others, trial and error continued until a successful accidental opening occurred. Primary interest was not in the amount of trial and error and insight and no statistical data were obtained on this point. Casual observation showed that neither trial and error nor insight seemed characteristic of any one age level. Since the aim was to get the subject to open the box without demonstration from E (this was not essentially a trial and error learning experiment), some aid was given if S began to tire and seemed loathe to continue trying. Three controls were kept in the giving of aid: (a) S was to complete all the necessary movements; (b) S was to use trial and error procedure for at least one minute before any aid was given; and (c) S was to be offered aid, if desirable, which took the form of language direction and pointing to the correct spot but not of performing the movement for the subject. In the reopening part of Experiment III, the same procedure was carried through.

A steady decrease with increasing age was found in the amount of aid needed and a steady increase with increases in the complexity of the boxes. In the relearning part of III, the per cent of times aid was needed was less than in the initial part of III and though still necessary for two-year olds was frequently not at all necessary for some of the three's and four's. Appreciably long latent mem-

ory spans were found with three- and four-year olds when 'achievement' was accomplished by a trial and error and relearning procedure. Shortest latent memory spans were found when relearning after initial trial and error opening was not permitted and were practically negligible with the two-year olds. Something seemed to be gained, however, in a single trial and error opening at all age levels in that the amount of trial and error used in an immediate reopening and the amount of aid needed was measureably reduced.

'Achievement' by means of a single trial and error procedure (IV) was followed by lower latent memory spans at all age levels and with all boxes than 'achievement' by demonstration. A trial and error and relearning procedure (III) however was not always followed by lower latent memory spans than those found with demonstration procedure.

Results showing a lower latent memory span for Type C box than for Type B and for Type A and a lower latent memory span after Procedure IV and III than II and I respectively were the general conclusions. Of the individual curves for the two-year olds, 88 per cent corroborated these data; for the three-year olds, 75 per cent; for the four-year olds, 63 per cent. Individual results showing Type B or/and Type C with longer latent memory spans than Type A or Experiment III with longer latent memory spans than II or I were occurring with greater frequency with the older children.

EVK, a well adjusted child of superior intelligence with a calm coöperative mind set, showed the average results very well in her graphs. MM, also a child of superior intelligence, with a highly negativistic personality who resisted demonstrations, who wished to do everything for herself, made remarkably higher scores in trial and error experiments which she obviously enjoyed. JAS, a reserved and too easily suggestible child, who showed little initiative, who looked to an adult constantly for permission to proceed, scored significantly lower on the trial and error experiments than on the demonstration ones. HS, who appeared more engrossed and attentive when complicated directions were being demonstrated and who disdained the seemingly simple, made better scores on Type C following demonstration than on Types A and B. Trial and error procedures at which times he went plunging blindly and with little direction and insight caused him great difficulty before he finally succeeded. His methods of work were such that failure to open the box, rather than stimulating him to further effort, tended to discourage him. He repeated with little self-consciousness, "I can't. You help me. No, I can't." And he proceeded to tug blindly. Trial and error for him proved to be of little value especially with the more difficult boxes.

RESULTS

1. Latent memory spans increased with age, generally following the negatively accelerated curve but showed variations which might have occurred when factors other than maturation alone were involved in the learning situation.

2. Latent memory spans were longer when 'achievement' was accomplished by demonstration involving auditory and visual stimuli than just the visual stimuli.

3. The number of demonstrations was greater when verbal directions were omitted.

4. Latent memory spans increased with increases in the number of demonstrations. Two-year olds were evi-

dently dependent on verbal directions to assist them in directing and maintaining their gaze for the visual directions. For them, increasing demonstrations without verbal directions did not result in increased latent memory spans, as it did with the three- and four-year olds, who were less dependent on verbal directions and profitted by the increase in demonstrations to increase latent memory spans.

5. Latent memory spans were usually shorter when trial and error procedure took the place of demonstration in the 'problem of achievement.'

6. Latent memory spans were negligible with two-year olds and with some three-year olds when relearning was not permitted after the trial and error opening.

7. With two-year olds, 'achievement' by demonstration with verbal directions resulted in the longest latent memory spans; trial and error and relearning resulted in short but appreciable ones; results after a single trial and error opening were negligible. Depending upon the procedure used for 'achievement,' the latent memory span range was:

	days
Type A box	3.3–8.4
Type B box	0.6–3.3
Type C box	0.3–2.0

8. With three- and four-year olds, an increased number of demonstrations (even though omitting verbal directions) resulted in longest latent memory spans; trial and error and relearning gave appreciable ones; single trial and error opening gave shortest ones. Depending upon the procedure used for 'achievement,' the latent memory span range for three-year olds was:

	days
Type A box	9.5–15.1
Type B box	4.4–10.9
Type C box	1.6– 6.1

and for four-year olds:

	days
Type A box	7.5–19.8
Type B box	5.5– 9.0
Type C box	2.9–11.7

9. The latent memory spans of subjects showing atypical personality traits and methods of work were correspondingly atypical in the light of the results found above.

It would seem that in learning, there was involved more than the one item—maturation of the functioning of memory. The richer experience of older children upon which they build associations does in general result in longer latent memory spans—the premise of maturation. But personality characteristics and methods of work have definite effects on latent memory spans. Wherever such personality traits and methods of work with regard to the situation were considered 'unusual,' unusual results were found in functioning memory. Functioning memory was also found to be inextricably tied up with the problem of 'achievement' and the complexity of the gestalt to be recalled. No absolute latent memory spans can be given even in an unemotionally toned learning situation such as described here—not even for the recall of movements in the successful opening of boxes.

Learning is dependent on memory, and functioning memory—the actual

latent memory span—seemed to be dependent on: (1) the complexity of the problem, (2) the method by which 'achievement' was accomplished, and (3) the personality characteristics and methods of work of the individual.

The interdependence of personality traits and method of 'achievement' in resultant learning should especially be noted. It raises the question of whether one should give special consideration to personality types and choose the most profitable method of achievement for maximum results in learning or whether one should attempt to change atypical personality traits, to bring them within the normal range for the greatest possible gain from *each* of the various methods of achievement.

Certainly for the two-year old, there seemed to be a necessity for verbal directions during a demonstration to assist him in directing and maintaining his gaze in order to grasp what was offered during the demonstration.

The Development of Concepts of Magnitude

MARTHA E. THRUM

THE development of the ability of children to perceive relative sizes of objects and make correct responses to the relation is a subject about which we know little. It is rather apparent that children have concepts which differ from those of adults in regard to comparative sizes of objects in their environment. It is often noted that a child misjudges size in relation to himself as is demonstrated by his look of surprise when he cannot sit in a chair made for a doll.

Attempts have been made to gain more complete and accurate information as to just how a child interprets things about him. This problem is particularly difficult with the very young child because of his inability to comprehend language and the greater limitation in conveying his thought through language which is intelligible to adults. This difficulty with language makes it necessary to attack the problem in a very simple and often indirect manner. Perhaps because of the comparative recency of planned research in child psychology, and perhaps because of the difficulties encountered in attempts to secure information regarding the extent of a child's ability to interpret relationships from an adult point of view, little work has been done on the subject.

Oppenheim (6) says that a child learns very gradually to associate visual impressions with proper relations of objects in space, and that his undeveloped power of accurate observation added to this, is bound to make his reports unreliable. Johnson (5) states that the child's perception of differences in the size and form of objects doubtless excels his ability to indicate his discrimination.

The purpose of this study was to obtain information on the development of abstract concept of magnitude for children from two to five years of age. The relative differences in size of geometric forms was chosen as a means of securing this information. For such young children it was necessary to have the procedure and language used as clear as possible. The sets of geometric forms were so planned that for each set of a given form the relative differences in size were varied. The sets included the familiar forms of circles, squares, and triangles, and were made of black cardboard. For a small group a further set was used which included colored forms. The colors used were red, green, yellow, and blue.

The investigations so far undertaken which bear on the problem of a child's concepts of size, fall into the fields of

form perception, the recognition of relationships, and the learning of relative sizes. There has been considerable work done on form and color combined in the same experiment in an attempt to determine which of the two elements tends to influence a child's selection: if there is a preference shown at what age this appears, how long a child tends to prefer color to form or vice-versa, and what factors seem to bring about a change of preference. These studies are primarily a study of preference and few investigations report data on the perception of the relative size of an object in comparison with others. A brief review of these experiments will suffice to illustrate the great need for further work.

Baldwin and Stecher (1) used the Montessori cylinders to test discrimination of difference in the diameters and heights of cylindrical inserts and their corresponding holes. Three sets of 10 cylinders were used, the first varying in diameter, the second in both diameter and height, and the third in height only. The inserts were placed and taken out again in front of the child before he was asked to perform the test. It was reported that several children took out correctly placed cylinders in the hope of forcing into the hole another cylinder for which a place could not be found, and that much trial and error experimentation went on.

The Montessori tower was used for perception of differences in size. It is comprised of ten blocks to be placed one on another in order of size. The tower was first built by the experimenter, then knocked down, and the child was asked to build it in the same way. The smaller blocks seemed easier than the larger ones. Perfect performance was impossible for the two-year-olds. The time necessary to complete the performance decreased with an increase in age. The authors say that the Montessori tower is an attractive and familiar occupation for young children and gives an immediate index of the development of a child's knowledge of size relationships.

An experiment by Rice (8) on the orientation of plane figures, though it uses figures of uniform size throughout the experiment, involves a keenness of perception similar to that involved in the discrimination of slight size differences. The problem was to test, if possible, the age when a child either will, negatively, refuse to recognize *sameness* in two figures which are identical, but not in the same position on the page, or will, positively, indicate by some word or action that they would be the same if one or the other were turned part way around.

The portion of the study important for consideration was a test of discriminative perception in the selection of a design regardless of position such as the perception of diamonds vertically and horizontally placed in the first test period, and of two spoons, vertically and horizontally placed in the second test period. The tests were given to 226 children between the ages of two years seven months and nine years three months. In the tests the scores depended on the number of correct perceptions including the accuracy of orientation.

The conclusions were that the orientation on the page of plane figures

appears to rise rather suddenly as a factor in their perception between the ages of five and six, or between the standard kindergarten age and the standard first grade age. The break is apparently rather sudden for the individual child with little or no transition; and for the group it may be located much more exactly than one might expect. The degree of similarity with the figures used in the perception tests seems to bear little or no relation to the reaction toward the orientation of the figures on the part of the child.

Piaget (7) holds that young children are unable to interpret relationships unless they are definitely concerned with themselves. On the other hand, Isaacs (4) and Hazlitt (2) found that children at a very young age were able to perceive and respond to relations that involved fine discriminations and a certain knowledge of relationships, but were unable, in many cases, to state these relationships because of their limited use of language. Other investigators interested in a child's ability to make judgments found that, in general, young children were able to see relative differences before they were able to state them.

A study of the *Learning of Abstract Concepts of Size* was undertaken by Hicks and Stewart (3). This is, as far as could be ascertained, the only experiment which deals with the abstract concepts of size irrespective of color or form and is of particular interest.

The problem was to test two to five year old children on their ability to learn to select the middle size of three boxes. Six boxes were used. They were cubes open on one side and varied in size from fourteen centimeters to four centimeters. All were covered with red paper. A small toy was always placed under the middle-size box in order to help motivate its selection and to identify the correct response to the child.

The 6 boxes made up 4 series with 3 boxes in each. Each series was presented in such order that after a child had learned to select the middle-size box in one group, he was shown a new combination from which the *largest* box of the previous series had been dropped and a new *smallest* box added. By varying the position of the boxes during each series the factor of position as a possible basis of learning was eliminated. During a single practice period the 5 positions of a series were repeated 5 times. Thus 15 trials or choices were made by a child in the course of each practice period. Each series was presented until the child made a perfect record on the 15 trials constituting a practice period. The next series was presented at the next practice period. A child was dropped at the end of the sixth practice period if he did not get more than a third of the responses correct. The interval between practice periods was never less than one or more than three days.

There were 40 children used in this experiment: 10 in each group for ages two, three, four and five years. The examiner placed a screen in front of the boxes when arranging them; then said, "now we are going to play a new game. Here is a middle-size box, a big box (pointing), and a tiny box (pointing). There is a toy under the middle-

size box, but there is nothing under the big box or tiny box (lifting each box up to demonstrate). Remember, the toy is always under the middle-size box." Before beginning the test on the succeeding days, the examiner said, "do you remember how we played our game? The toy was always under the middle-size box. All right, find the toy for me."

The authors summarize their results as follows: The test was beyond the ability of 9 of the 10 two-year-olds; 52 per cent of the choices of the 9 children who failed the test were made on the basis of the position of the box; the 31 children who completed the test gave almost no evidence of selection on the basis of position; the number of errors and the number of practice periods decreased with age; success in learning the test correlated highly with the mental age for 10 of the three-year-old children; direction of attention to the boxes and an interest in making the correct choices were factors in success; the children who completed the test confused the middle-size box with the large one twice as often as with the smallest one; 68 per cent of the errors made by the 31 children who completed the test were on Series 1. Once having learned the concept of *middle-sizeness* in the first series of boxes, they were able to apply this concept to the succeeding series.

The writer's experience with children under experimental conditions, leads her to think that the low percentage of success among the younger groups might have been due to the long practice periods. The authors state that "direction of attention to the boxes and an interest in making correct choices were factors in success." Since a child was obliged to complete a practice period at one sitting, and since each practice period required 15 trials or choices, is it any wonder that a two-year-old child lost interest? Another factor which the writer questions is that a child was dropped at the end of the sixth practice period if he did not get more than a third of the responses correct. This is requiring the same standard for the two-year-olds that was required of the five-year-olds. To say that a two-year-old cannot learn to select the middle-size of 3 boxes because he takes a greater number of trials to do so, is hardly correct. It would be interesting had the experimenters found out how many trials were required of each age group.

PROBLEM

This investigation, a report of which follows, is concerned with the development of the concept of magnitude. The major problem was a study of a child's development of the concepts of big, little, and middle size, irrespective of the particular sizes presented. The experiment covered a period of several months. In this experiment there were three series of tests given: A preliminary series, or Series X; a series forming the main study, or Series Y; and a supplementary series, or Series Z in which colored cards were employed. The children who reacted in this study were enrolled in the Child Institute of the Johns Hopkins University. They ranged in age from two to four and a half years at the begin-

ning of the study. The records of 34 children were used. There were 20 boys and 14 girls.

Method and Results

Series X. The materials used in the preliminary series of this experiment were as follows: 3 bright red toy automobiles measuring 4¼ inches, 3 inches, and an 1¼ inches respectively in length; 3 white paper circles the diameters of which measure 4 inches, 2¼ inches, and ¾ inch respectively; 3 white squares, the sides of which measure 4 inches, 1½ inches, and ½ inch respectively. The automobiles were used because they were familiar to and liked by all the children. They were exactly alike except in size. The objects in Series X were presented in the following order: cars, circles, squares, and triangles. The children were allowed to play with the cars for a few minutes before they were placed in position for the experiment. If a child wanted to continue playing, he was told that after playing the "game" with the experimenter he could play with the cars alone for a few minutes.

In the testing situation the examiner placed the cars on a table in front of the child who sat opposite, then gave the directions: "Look at these (pointing to objects) very carefully and give me the one I ask you for. Give me the biggest one." The first sentence of the above directions was repeated for each testing situation. The second sentence was varied according to the relative size of the object which the particular test situation called for. The positions in which the materials were presented, and the size which the examiner asked for, are indicated in the chart given below;

Position	*Sizes requested*
1. Big, little, middle size	Big
2. Big, little, middle size	Little
3. Big, little, middle size	Middle size
4. Middle size, little, big	Middle size
5. Middle size, big, little	Middle size

It will be noticed that the object intermediate in size was never placed in the middle position in this series. The order of presentation and size requested, as given in the chart, were followed for all materials used in Series X. The subject was given no indication of the correctness of his choice. Only one choice was required of a subject at each sitting, *i.e.* five sittings were necessary to complete Series X.

Results. The results have been tabulated in various ways in order to find out what factors seemed to influence a child's choice of a particular size. The data are analyzed for the number of errors made in response to requests for particular sizes of objects in relation to the other objects presented and also for the order of presentation with reference to size. The possible influence of the form of the object is also considered.

The data for errors made in response to requests for a particular size, either big, little, or middle size, are given in table 1. By far the greatest number of errors were made for the middle size, fewer for the little one, and least for the big one. We find that 88 per cent of the choices were correct when the big object was requested, 68 per cent when the little object was requested, and 48 per cent when the middle size was requested. The per-

centage of errors in 20 choices ranged from zero to eighty per cent, with a mean of 41.6 per cent of errors for the group. Five children out of 25 chose correctly for all selections of the three sizes. These children ranged in age from three years eleven months to four years eight months. The greatest number of errors made for the three sizes was 16 out of 20 choices, made by 2 children, 1 three years and eleven months old, and the other two years and five months old.

TABLE 1

Series X

Errors made in relation to size requested

REACTOR	AGE	NUMBER OF ERRORS				ERRORS IN 20 CHOICES
		Size requested			Total	
		Big	Little	Middle		
						per cent
1	2–1	4	3	7	14	70
2	2–	0	3	0	3	15
3	3–4	0	2	7	9	45
4	3–3	0	2	0	2	10
5	3–	0	0	12	12	60
6	3–6	0	0	10	10	50
7	2–11	0	2	11	13	65
8	3–1	0	1	12	13	65
9	3–11	4	4	8	16	80
10	3–11	0	0	0	0	00
11	2–5	0	0	12	12	60
12	2–5	0	4	12	16	80
13	3–2	0	3	12	15	75
14	2–4	2	1	9	12	60
15	3–7	0	0	0	0	00
16	4–6	0	0	8	8	40
17	4–	0	0	1	1	05
18	4–6	0	0	0	0	00
19	3–5	0	2	11	13	65
20	2–7	2	4	9	15	75
21	2–4	0	0	2	2	10
22	3–8	0	1	1	2	10
23	4–8	0	0	0	0	00
24	4–5	0	0	0	0	00
25	4–7	0	0	12	12	60
Total errors.....		12	32	156	200	
Number of choices...		100	100	300		
Per cent wrong.....		12	32	52		
Per cent correct.....		88	68	48		

TABLE 2

Series X

Percentage correct for order of presentation

REACTOR	PERCENTAGE CORRECT		
	Order presented		
	BLM	MLB	MBL
1	41	25	00
2	75	100	100
3	50	100	25
4	83	100	100
5	67	00	00
6	67	00	50
7	50	00	25
8	58	00	00
9	100	100	100
10	33	00	00
11	67	00	00
12	33	00	00
13	41	00	00
14	58	00	25
15	100	100	100
16	67	00	100
17	92	100	100
18	100	100	100
19	58	00	00
20	17	00	75
21	83	100	100
22	83	100	100
23	100	100	100
24	100	100	100
25	67	00	00
Mean.....	68	45	52

The mean per cent of correct choices for the order of presentation, BLM (big, little, and middle size) in which all 3 sizes were requested, was 68. For the order MLB, in which only the middle size was requested, there was a mean per cent of correct choices

of 45. The data for individual children are given in table 2. With the exception of one child, we find that the children were either 100 per cent correct in their choice of the middle size for all forms presented, or were 100 per cent incorrect. Eleven out of the 25 children were 100 per cent correct. The mean per cent of correct choices of the middle size in the order MBL was 52. There were 11 children who were 100 per cent correct in their selections in this order of presentation.

Another factor involved in the problem was the difference in form of the objects used. In table 3, the number of errors made for each of the forms presented are given. As has been stated above, the cars were used because of their immediate appeal. On the whole, fewer errors were made with the cars than with the geometric forms, the circles, squares, and triangles; but the difference was slight. Sixty-three per cent of the choices involving the cars were correct, 58 per cent correct for the circles, 59 per cent correct for the squares, and 60 per cent correct for the triangles.

Summary. The results indicate that more children were familiar with the idea of *big* in relation to the other two sizes presented than they were with little or middle size. Only 4 out of the 25 children made errors in their selection of the big forms, while 13 made errors when selecting the little one, and all but 7 made errors in their choice of the middle size form. The ages of the 4 children who made errors for the big form were two years one month, two years four months, two years seven months, and three years eleven months. These children made errors in their selections of the little and middle size forms also. Among those who made no errors in their selection of the big forms there were 4 who were not three years lod. They ranged from two years to two years

TABLE 3

Series X

Errors made in relation to form presented without reference to size requested

REACTOR	ERRORS MADE				
		Forms presented			
	CARS	Circles	Squares	Triangles	TOTAL
1	2	4	4	4	14
2	0	1	1	1	3
3	1	3	3	2	9
4	0	1	0	1	2
5	3	3	3	3	12
6	2	2	3	3	10
7	3	3	4	3	13
8	3	3	4	3	13
9	4	4	4	4	16
10	0	0	0	0	00
11	3	3	3	3	12
12	4	4	4	4	16
13	3	4	4	4	15
14	3	3	3	3	12
15	0	0	0	0	00
16	2	2	2	2	8
17	1	0	0	0	1
18	0	0	0	0	00
19	3	4	3	3	13
20	3	5	3	4	15
21	1	1	0	0	2
22	2	0	0	0	2
23	0	0	0	0	00
24	0	0	0	0	00
25	3	3	3	3	12
Total errors.....	46	53	51	50	200
Number of choices..	125	125	125	125	
Per cent wrong.....	37	42	41	40	
Per cent correct.....	63	58	59	60	

and eleven months. It would appear therefore that age had very little, if any, influence over the accuracy of selections.

It is difficult to determine what effect the order of presentation of the three sizes had upon the choices. In the positions MLB and MBL, in which only the middle size was requested, more errors were made in the first of these positions than in the second, but whether this was due to the position or to a learning factor, it is impossible to say.

Another factor which was analyzed in order to determine its effect upon the accuracy of selections was the difference in forms presented. Although the cars, which were presented first, were chosen correctly more often than the three geometric forms, the difference was not great, and the difference in relative accuracy among the geometric forms was negligible. It appears therefore that the various forms used had no appreciable influence on the correctness of the choice.

The accuracy of selections in this series seems to have been determined by the previous experiences of the child, rather than by any factors involved in the experiment itself.

Method and Result

Series Y. Following the preliminary series which was intended primarily to secure coöperation and understanding of instructions, Series Y was given. This series was presented to a group of 15 children twice, and to a group of 19 children once only. A retest was given to one group after an interval of 6 months to obtain an indication of the effect of ordinary experiences upon the development of concepts after the stimulation of the test experience. The materials were sets of black cardboard circles, squares, and triangles differing in size by 1 inch, ½ inch, and ¼ inch in diameter or length of side. The largest circle was 3 inches in diameter and the smallest 1 inch; the largest square and triangle measured 3 inches on a side, and the smallest measured 1 inch. For each geometric form the order of placement relative to size was the same: that is,

Circles	Squares	Triangles
BLM	MBL	LMB

B represented big, L represented little, and M represented middle size. There were five steps which involved varying differences in the sizes of the forms used. The first step included forms that differed from each other by 1 inch in diameter or length of side, the second by ½ inch, and the third by ¼ inch. In the fourth step there was a difference of 1 inch between the biggest and middle size card; in the fifth there was ½ inch between the biggest and the middle size card, and ¼ inch between the middle size and the little card. A sixth step was introduced in which all the three forms used were 1 inch in diameter or in length of side. The last step was used as a check on a child's understanding of the problem. The remarks made by the children were recorded by the experimenter. The directions were the same as for the other five steps, *i.e.* the child was requested to give the examiner the biggest, littlest, or middle size one. As in Series X, the geometric forms were placed on a table

in front of a child who sat opposite the examiner.

The positions in which the forms were presented and the sizes requested are indicated in the following chart:

Group A

Circles, Position BLM. Big requested in the six steps.
Squares, Position MBL. Big requested in the six steps.
Triangles, Position LMB. Big requested in the six steps.

Group B

Circles, Position BLM. Little requested in the six steps.
Squares, Position MBL. Little requested in the six steps.
Triangles, Position LMB. Little requested in the six steps.

Group C

Same forms and positions as in Groups A and B. Middle size requested.

In this series the middle size was put in the intermediate position once. A child was requested to make only three choices a day. He was, for example, asked to select the big size form in the first step of the first group above, for the circles, squares, and triangles. The next day, he completed the second step in which the differences in size of the forms varied from the preceding step. This procedure was continued until he had finished the six steps for the three forms. A similar procedure was followed for the second group B, in which the little size was requested, and for the third group C, in which the middle size was requested. The directions given were the same as those used in the preliminary series; that is, the child was requested to give the examiner the biggest, littlest, or middle size one according to the particular test situation.

Results. The same factors were considered in the tabulation of the results of this series as were considered in Series X.

In table 4, the number of errors made in relation to the size requested is given. We see that although the number of children who were correct in their selection of the big forms was less than the number of those who were incorrect in their selection of the little forms, the total number of errors made to the request for the biggest was greater than for the little form. Ten children made 61 errors in the selection of the biggest and 12 children made 48 errors in the selection of the little card. This gives a percentage of correct choices of 88 for the biggest and 91 for the littlest form. The number of errors made in selecting the middle size was significantly larger. Only 6 out of 34 children were constantly correct in their selection of this size. There was a total number of errors for the group of 264, which gave a percentage of correct choices of only forty-eight. The six children who were correct in their selections of this size were correct also in all their selections of the big and little forms. The youngest child to choose all forms correctly was three years and three months; the others ranged from three years and seven months in age to four years and eight months. The percentage of errors in 45 choices ranged from zero to sixty-seven, with a mean of 22.

The various arrangements of the sizes used made it possible to have 6

TABLE 4

Series Y

Errors made in relation to size requested

REACTOR	AGE	NUMBER OF ERRORS				PER CENT ERRORS IN 45 CHOICES
		Size requested				
		Big	Little	Middle	Total	
1	2-4	6	2	15	23	51
2	2-3	0	0	14	14	31
3	3-4	0	0	2	2	04
4	3-6	0	0	0	0	00
5	3-4	0	0	1	1	02
6	3-9	0	2	2	4	09
7	3-1	0	0	11	11	24
8	3-5	1	0	15	16	35
9	4-2	4	0	2	6	13
10	4-1	0	0	14	14	31
11	3-1	0	0	12	12	24
12	2-8	0	0	12	12	24
13	3-5	0	1	10	11	24
14	2-4	13	0	9	22	49
15	3-9	0	0	0	0	00
16	4-8	0	0	0	0	00
17	4-2	0	0	0	0	00
18	4-8	0	2	5	7	15
19	3-7	0	1	15	16	35
20	2-11	4	2	7	13	29
21	2-7	6	3	14	23	51
22	3-10	0	0	8	8	18
23	4-10	0	0	0	0	00
24	4-8	0	0	0	0	00
25	4-10	0	0	1	1	02
26	4-11	0	1	6	7	15
27	3-7	6	0	15	21	47
28	3-8	0	0	8	8	18
29	2-3	7	10	11	28	62
30	3-6	0	0	1	1	02
31	2-3	3	15	12	30	67
32	2-5	11	3	12	26	58
33	3-9	0	0	15	15	33
34	3-0	0	6	15	21	47
Total errors		61	48	264	373	
Number of choices		510	510	510		
Per cent wrong		12	09	52		
Per cent correct		88	91	48		

TABLE 5

Series Y

Percentage of correct responses for varying differences between size of form requested and of form selected

REACTOR	DIFFERENCE IN INCHES BETWEEN DIAMETERS OR LENGTH OF SIDES						MEAN
	2	1½	1	¾	½	¼	
1	100	83	67	100	70	61	80
2	100	100	83	100	80	72	89
3	100	100	97	100	100	95	99
4	100	100	100	100	100	100	100
5	100	100	95	100	100	100	99
6	100	100	100	100	100	78	96
7	100	100	100	100	80	72	92
8	100	100	90	100	80	61	88
9	100	100	89	100	97	83	95
10	100	100	83	100	80	72	89
11	100	100	100	100	80	67	91
12	100	100	95	100	80	72	91
13	100	100	83	100	87	78	91
14	100	100	83	100	70	45	83
15	100	100	100	100	100	100	100
16	100	100	100	100	100	100	100
17	100	100	100	100	100	100	100
18	100	100	83	100	90	95	95
19	100	100	85	100	80	60	87
20	67	100	78	100	87	83	86
21	100	100	67	100	67	60	82
22	100	100	100	100	80	89	95
23	100	100	100	100	100	100	100
24	100	100	100	100	100	100	100
25	100	100	100	100	100	95	99
26	100	100	95	100	90	83	95
27	100	67	78	67	80	67	76
28	100	100	100	100	87	78	94
29	83	83	56	83	63	67	72
30	100	100	100	100	100	95	99
31	33	50	45	50	61	83	54
32	67	67	72	67	70	67	68
33	100	100	83	100	80	67	88
34	100	100	78	100	73	56	84
Mean	95	95	87	96	86	79	

size differences in the 6 steps of this phase of the experiment. Table 5 shows us the percentage of correct responses for varying differences be-

tween the size of the form requested and the form selected. The actual measurements of these differences in inches were 2; 1.5; 1; 0.75; 0.50; and 0.25. The mean per cents of correct choices for the group of 34 children for these differences between the size of the form requested and the form selected were 95, 95, 87, 96, 86, and 79, respectively. These percentages indicate greater difficulty for the smallest differences in size of forms, with the exception of the one inch difference. This variation in trend appears to be due to a few low scores for that size difference that were highly influential upon the mean for so small a group. The trend toward greater difficulty with smaller size differences is indicated by the decrease in percentage correct for the majority of the group. In this table will be found also the mean of the percentages of correct choices for each child for all these size differences. The range was from fifty-four to one hundred per cent correct.

The results were analyzed with regard to the possible effect of the order of presentation of the three sizes upon the accuracy of selections. Table 6 shows that the mean percentage of correct selections for the three orders BLM, MBL, and LMB was 76, 75, and 76, respectively. This would indicate that the order of presentation did not influence the selections.

The number of errors made by each child for each of the three forms used was approximately the same. Nine children made all their selections of may be seen in table 7. The total number of errors made for each form circles and squares correctly, and 10 children made their selections of triangles correctly.

TABLE 6

Series Y

Percentage correct for order of presentation

REACTOR	PERCENTAGE CORRECT		
	Order presented		
	BLM	MBL	LMB
1	47	47	53
2	67	67	73
3	87	100	100
4	100	100	100
5	93	100	100
6	93	80	100
7	73	73	80
8	60	67	67
9	67	73	67
10	93	93	73
11	73	73	73
12	80	73	67
13	67	67	93
14	47	47	60
15	100	100	100
16	100	100	100
17	100	100	100
18	87	73	93
19	60	67	67
20	73	80	60
21	67	33	47
22	80	87	80
23	100	100	100
24	100	100	100
25	100	93	100
26	87	80	87
27	53	53	53
28	100	73	73
29	27	53	33
30	100	100	93
31	40	33	27
32	47	40	40
33	67	67	67
34	40	60	60
Mean...	76	75	76

Only 15 children commented on the sixth step of this series in which all three sizes of the 3 forms presented

TABLE 7

Series Y

Errors made in relation to form presented without reference to size requested

REACTOR	NUMBER OF ERRORS			
	Position and form presented			Total
	BLM Circles	MBL Squares	LMB Triangles	
1	8	8	7	23
2	5	5	4	14
3	2	0	0	2
4	0	0	0	00
5	1	0	0	1
6	1	3	0	4
7	4	4	3	11
8	6	5	5	16
9	1	1	4	6
10	5	4	5	14
11	4	4	4	12
12	3	4	5	12
13	5	5	1	11
14	8	8	6	22
15	0	0	0	00
16	0	0	0	00
17	0	0	0	00
18	2	4	1	7
19	6	5	5	16
20	4	3	6	13
21	5	10	8	23
22	3	2	3	8
23	0	0	0	00
24	0	0	0	00
25	0	1	0	1
26	2	3	2	7
27	7	7	7	21
28	0	4	4	8
29	11	7	10	28
30	0	0	1	1
31	9	10	11	30
32	8	9	9	26
33	5	5	5	15
34	9	6	6	21
Total errors..	124	127	122	373
Number of choices.....	510	510	510	
Per cent wrong.....	24	25	24	
Per cent correct.....	76	75	76	

were alike. All the other children selected a form without saying anything. The remarks are recorded below. The numbers representing particular children correspond to those used in the tables.

These comments give emphasis to the results from the other forms in showing that some children have a clear perception of relative differences. Some children show stability in judgments of size relations and others appear less secure, indicating that the ages studied form a period of rapid development of concepts of magnitude.

Summary. The results of Series Y are in agreement with those found in the preliminary series. The majority of the children had little trouble in making their selections when the biggest and the littlest forms were requested, but most of them seemed unable to select the middle size of the three forms, regardless of the actual differences in size between the forms. Although the largest differences were between the two extremes of the three presented, the differences between the middle-size in relation to the other two were large and the children had no difficulty in reacting to those differences when they involved selections of the big or little.

The concept of middle-sizedness proved to be much more difficult than that of big or little size. As has been pointed out, the factors of age, order of presentation, and forms used seemed to have been insignificant in their influence upon the accuracy of selections.

Retest, Series Y. A retest in Series Y was given to a group of fifteen children after a summer vacation. This

REACTOR	AGE	SIZE REQUESTED	REMARKS
2	2–3	Little	"Well, they're all little."
5	3–4	Big	"I can't find the biggest one."
		Middle	"They're so little I don't know which is the middle-size one."
7	3–1	Middle	"You mean that big one?" (The forms in the other five steps had been placed in the order MBL.)
9	4–2	Big	"Didn't look like the biggest one."
			"Had to look carefully 'cause I had to see which was the biggest one."
		Little	"I can't tell which is the littlest one. They seem all big, don't they?"
		Middle	"I don't see any to give you. I'll give you this one." (Chose one on his right.)
10	4–1	Big	"It hasn't any biggest one."
			"There isn't any biggest one on this one."
		Little	"They're all little."
		Middle	"Those are little."
11	3–1	Big	"Where is it?"
12	2–8	Big	"It's no big one. This one must be it." (Handed me one on her left, where the big one had been in the previous five steps where the position had been BLM.)
13	3–5	Middle	"These were the same size, weren't they?"
14	2–4	Big	"These littlest ones. Those are little ones. Those are little ones."
		Middle	"All these middle-size ones."
26	4–11	Big	"Where's the biggest one?"
27	3–7	Big	"Was that the biggest one?" (Chose one in middle. Order was LMB.)
16	4–8	Middle	"They're so small, aren't they? I don't know what's the matter with them."
19	3–7	Middle	"They're all middle size."
23	4–10	Little	"I can hardly tell which is the little one of these." (On the following day when the various sizes in the first step were presented she said: "I know which is the middle size of these because the middle-size one is more middle-size."
		Middle	"I can hardly tell. Could'nt tell with those because they're all the same size."
25	4–10	Little	"They're all little ones, aren't they? Oh, is this the one? It looks like it." (Chose the one on his right.)

was done in order to find out what effect their experiences during those four months would have upon the

accuracy of their selections, and to refamiliarize the children with the test situation before introducing the next phase of the experiment. The method of procedure was the same as that used in the original test.

Results. The children made no errors in their choices of the big forms,

TABLE 8

Series Y, Retest

Errors made in relation to size requested

REACTOR	AGE	NUMBER OF ERRORS				PER CENT ERRORS IN 45 CHOICES
		Size requested				
		Big	Little	Middle	Total	
1	3-1	0	0	11	11	24
2	3-0	0	0	3	3	07
3	4-0	0	0	6	6	13
4	4-3	0	0	1	1	02
5	4-0	0	1	3	4	09
6	4-6	0	0	0	0	00
7	3-10	0	0	4	4	09
8	4-1	0	1	14	15	33
9	4-10	0	0	6	6	13
10	4-9	0	0	0	0	00
11	3-9	0	0	1	1	02
12	3-5	0	0	1	1	02
13	4-4	0	0	10	10	22
14	3-0	0	0	15	15	33
15	4-6	0	0	0	0	00
Total errors.....		0	2	75	77	169
Number of choices..		225	225	225		
Per cent wrong.....		00	00.8	33		
Per cent correct....		100	99.2	67		

as is shown in table 8, only 2 errors when making a selection of the little forms, and 75 errors when selecting the middle-size forms. Three children made all their selections of the 3 sizes correctly. The percentage of errors in 45 choices ranged from zero to thirty-three, with a mean of 11.

The mean percentages of correct choices for the six differences in size between the forms requested and those selected are tabulated in table 9. For the size differences of 2, 1½, 1, ¾, ½, and ¼ inches we find mean percentages of 100, 100, 96, 100, 94, and 87 respectively. In other words, the difference of 2 inches, 1½ inches, and

TABLE 9

Series Y, Retest

Percentage of correct responses for varying differences between size of form requested and form selected

REACTOR	DIFFERENCE IN DIAMETER OR SIDE, IN INCHES						MEAN
	2	1½	1	¾	½	¼	
1	100	100	83	100	83	83	91
2	100	100	100	100	97	89	98
3	100	100	100	100	90	83	95
4	100	100	100	100	100	95	99
5	100	100	100	100	97	83	97
6	100	100	100	100	100	100	100
7	100	100	100	100	97	83	97
8	100	100	83	100	83	61	88
9	100	100	100	100	90	89	96
10	100	100	100	100	100	100	100
11	100	100	100	100	100	95	99
12	100	100	100	100	100	95	99
13	100	100	89	100	87	78	92
14	100	100	83	100	80	67	88
15	100	100	100	100	100	100	100
Mean.	100	100	96	100	94	87	96

¾ inch were chosen correctly 100 per cent of the time; the difference of 1 inch was chosen correctly 73 per cent of the time; that of ½ inch was chosen correctly 40 per cent of the time; and the difference of ¼ inch 20 per cent of the time.

Table 10 shows us the mean percentage of correct choices for the order of presentation. We see that for the

order BLM the group made a mean percentage of correct selections of 87, for the order MBL a mean percentage of 87, and for the order LMB a mean percentage of 92.

An analysis of the number of errors made for the three forms used is shown in table 11. We find that 18, or the fewest errors, were made for the triangles, 30 for the squares, and 29 for the circles.

TABLE 10

Series Y, Retest

Percentage correct for order of presentation

REACTOR	PERCENTAGE CORRECT			
	Order presented			Total
	BLM	MBL	LMB	
1	80	67	80	227
2	93	93	93	279
3	80	87	93	260
4	100	93	100	293
5	80	93	100	273
6	100	100	100	300
7	87	100	87	274
8	67	60	73	200
9	100	100	100	300
10	93	80	87	260
11	93	100	100	293
12	100	93	100	293
13	67	67	100	234
14	67	67	67	191
15	100	100	100	300
Mean.	87	87	92	

A comparison of the first and second tests in Series Y shows us a decided improvement in the retest. There were 24 errors in the selections of the big forms in the first test and none in the retest. In the selections for the little forms in the first test there were 5 errors and in the retest only 2. In the selections of the middle-size forms there were 119 errors in the first test and 75 in the retest. One child who had made 14 errors out of 15 selections for the middle-size form in the first test made no errors for this size in the retest.

TABLE 11

Series Y, Retest

Errors made in relation to form presented without reference to size requested

REACTOR	NUMBER OF ERRORS			
	Form presented			Total
	BLM Circles	MBL Squares	LMB Triangles	
1	3	5	3	11
2	1	1	1	3
3	3	2	1	6
4	0	1	0	1
5	3	1	0	4
6	0	0	0	0
7	2	0	2	4
8	5	6	4	15
9	1	3	2	6
10	0	0	0	0
11	1	0	0	1
12	0	1	0	1
13	5	5	0	10
14	5	5	5	15
15	0	0	0	0
Total errors.	29	30	18	77
Number of choices.....	225	225	225	
Per cent wrong.....	13	13	08	
Per cent correct.....	87	87	92	

The trend for the mean percentages of correct choices for the varying differences between the size of the forms requested and those selected is the same for the retest as we found in the first test. All the children improved in their individual selections for the six differences except three.

The mean percentages of correct choices for these three children showed the largest decrease to be four points.

The mean percentages of correct selection for the order of presentation for the retest showed a considerable improvement, with a similar trend toward greater accuracy in selection of the middle-size form when it was presented in the middle position. Similar results were found in the analysis of the number of errors for the forms presented.

Method and Results

Series Z, Colored Forms. Colored forms were introduced in an attempt to find out whether the children would be influenced by color when the choice was to be made for size. It was assumed that the introduction of color might have an index of reliability of previous selections. The material for this series consisted of a set of colored geometric forms, circles, squares, and triangles of the same dimensions as those used in Series Y. They were presented in similar manner with the same size relationships maintained step by step as had been used in Series Y. In this series the sixth step in which all three forms were the same size was omitted. In the order of presentation of the colors, care was taken not to have any color occur more often than another, or in any position more often than another. The colors used were red, blue, yellow, and green. Black forms were mixed with the colored ones.

Instead of requiring the children to complete only one step of the experiment a day, as had been done in Series X and Series Y, they were requested to complete 3 steps 1 day and 2 the next. The 3 steps required nine choices a day, which took, at most, ten minutes. If, for any reason, the experimenter decided that a child was not concentrating on the task, the test period was shortened and he was requested to make only three choices. This series was presented to 24 children.

Results. Table 12 is a tabulation of the number of errors made in relation to the size of the form requested. We find that all the children except three were able to make correct selections when the biggest forms were requested. Those 3 children made 16 errors. Six children were incorrect in their selections of the littlest forms, and they made 20 errors altogether. These low percentages of errors, 4 per cent for the big form and 5 per cent for the little form, were not found for the middle size. When this size was requested 18 children made 140 errors, giving us a percentage of errors of 38, which is a considerable decrease in accuracy. Only 6 children were 100 per cent correct in all their selections of the 3 sizes.

Data for an analysis of the results with respect to the percentage of correct responses for the varying differences between the size of the form requested and the form selected are given in table 13. There were 6 possible differences, measured in inches, between the diameters or length of sides of the forms used. We find a mean per cent correct for the group of 98, 98, 91, 98, 90, and 84, for the differences of 2, $1\frac{1}{2}$, 1, $\frac{3}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$ inches respectively. The 2 children who chose incorrectly when there were

differences of 2 inches, 1½ inches, and ¾ inch between the size of the form requested and that selected were the youngest in the group.

TABLE 12

Series Z

Errors made in relation to size requested

REACTOR	AGE	NUMBER OF ERRORS				PER CENT ERRORS IN 45 CHOICES
		Size requested				
		Big	Little	Middle	Total	
1	3–4	0	0	11	11	24
2	3–3	0	0	0	0	00
3	4–3	0	0	2	2	04
4	4–6	0	0	0	0	00
5	4–4	0	0	5	5	11
6	4–9	0	0	0	0	00
7	4–2	0	0	7	7	15
8	4–4	0	0	7	7	15
9	5–1	0	0	4	4	09
10	5–2	0	0	0	0	00
11	4–1	0	0	0	0	00
12	3–10	0	0	0	0	00
13	4–8	0	1	2	3	07
14	3–4	0	0	15	15	33
15	4–9	0	0	1	1	02
26*	4–11	0	1	15	16	35
27	3–9	3	2	9	14	31
28	3–10	0	0	10	10	22
29	2–5	4	6	12	22	49
30	3–8	0	0	3	3	07
31	2–5	9	7	10	26	58
32	2–7	0	3	10	13	29
33	3–11	0	0	9	9	20
34	3–1	0	0	8	8	18
Total errors.....		16	20	140	176	
Number of choices...		360	360	360		
Per cent wrong.....		04	05	38		
Per cent correct.....		96	95	62		

* The reactors designated in previous series by the numbers 16–25 were not tested in Series Z.

In table 14, we found that the mean percentage of correct choices was greatest for the triangles, the 3 sizes of which were always placed in the order LMB. If the differences between the triangles and the squares and circles had been greater, we may have explained it by the fact that the triangles were presented last, but the difference is so slight that this factor may be considered negligible.

The order of presentation of the 3 sizes had as little influence upon the

TABLE 13

Series Z

Percentages of correct responses for varying differences between size of form requested and form selected

REACTOR	DIFFERENCE IN INCHES BETWEEN DIAMETERS OR LENGTH OF SIDE						MEAN
	2	1½	1	¾	½	¼	
1	100	100	83	100	87	78	91
2	100	100	100	100	100	100	100
3	100	100	100	100	100	89	98
4	100	100	100	100	100	100	100
5	100	100	100	100	90	89	96
6	100	100	100	100	100	100	100
7	100	100	100	100	90	78	95
8	100	100	89	100	90	89	95
9	100	100	100	100	93	89	97
10	100	100	100	100	100	100	100
11	100	100	100	100	100	100	100
12	100	100	100	100	100	100	100
13	100	100	95	100	100	89	97
14	100	100	83	100	80	67	88
15	100	100	100	100	90	100	98
26	100	100	83	100	80	61	87
27	100	100	78	100	80	45	84
28	100	100	89	100	87	78	92
29	83	83	72	83	70	72	77
30	100	100	100	100	97	89	97
31	83	67	61	67	73	67	69
32	100	100	83	100	80	72	89
33	100	100	83	100	90	83	93
34	100	100	83	100	97	95	96
Mean.	98	98	91	98	90	84	85

accuracy of selections in this series as in the two previous series. The mean per cent of correct choices for the orders BLM, MBL, and LMB were 82, 84, and 85, respectively. The individual scores can be found in table 14.

TABLE 14

Series Z

Percentage correct for order of presentation

REACTOR	PERCENTAGE CORRECT		
	Form and Order presented		
	Circles BLM	Squares MBL	Triangles LMB
1	67	80	80
2	100	100	100
3	87	100	100
4	100	100	100
5	87	87	93
6	100	100	100
7	80	87	87
8	87	87	80
9	100	100	100
10	87	100	87
11	100	100	100
12	100	100	100
13	93	93	93
14	67	67	67
15	100	100	93
26	67	67	60
27	53	60	93
28	100	67	67
29	33	60	60
30	93	100	87
31	20	47	60
32	73	67	73
33	80	80	80
34	93	67	87
Mean...	82	84	85

The number of errors made in relation to the form presented without reference to size requested is analyzed in table 15. We find that the total number for the circles, squares, and triangles was 65, 59, or 52 errors respectively. The greatest number of errors made by a child was 26 out of a possible 45 choices, made by a girl two years and five months old. These errors were for the three forms: 12

TABLE 15

Series Z

Errors made in relation to form presented without reference to size requested

REACTOR	ERRORS MADE			
	Position and Form presented			Total
	BLM Circles	MBL Squares	LMB Triangles	
1	5	3	3	11
2	0	0	0	00
3	2	0	0	2
4	0	0	0	0
5	2	2	1	5
6	0	0	0	0
7	3	2	2	7
8	2	2	3	7
9	2	0	2	4
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	1	1	1	3
14	5	5	5	15
15	0	1	0	1
26	5	5	6	16
27	7	6	1	14
28	0	5	5	10
29	10	6	6	22
30	1	0	2	3
31	12	8	6	26
32	4	5	4	13
33	3	3	3	9
34	1	5	2	8
Total errors..	65	59	52	176
Number of choices.....	360	360	360	
Per cent wrong.....	18	16	15	
Per cent correct.....	82	84	85	

for the circles, 8 for the squares, and 6 for the triangles.

An analysis of the relative accuracy of choices involving five colors, including black, is based upon data given in table 16. We see that the mean per-

TABLE 16

Series Z

Percentage correct for all sizes and forms

REACTOR	BLUE	GREEN	RED	YELLOW	BLACK	MEAN
1	70	86	71	75	78	76
2	100	100	100	100	100	100
3	100	100	85	100	90	95
4	100	100	100	100	100	100
5	89	85	100	91	82	89
6	100	100	100	100	100	100
7	89	87	100	90	69	87
8	90	75	87	89	80	84
9	100	100	87	82	90	92
10	100	100	100	100	100	100
11	100	100	100	100	100	100
12	100	100	100	100	100	100
13	90	100	78	100	100	94
14	67	67	83	64	60	68
15	100	100	100	100	90	98
26	75	67	83	54	55	65
27	87	67	62	64	50	66
28	78	78	85	73	87	80
29	57	60	72	44	83	63
30	90	100	85	100	90	93
31	28	50	55	46	37	43
32	100	55	75	67	50	69
33	78	80	85	75	85	81
34	80	78	85	83	85	82
Mean.	86	85	86	83	82	84

centages of correct selections for blue, green, red, yellow, and black were 86, 85, 86, 83, and 82, respectively. The small differences in errors for the varying colors indicate that the color of the form had little influence upon the selections made for relative size.

Although there were 16 errors made in the selection of the big form, all of them were made by the group of children numbered in table 12 from twenty-six to thirty-four. The entire series of tests from X to Z had been presented to these children within a period of six months. The first group of 15 children received the tests over a period of a year and three months. They received also a retest in Series Y which gave them greater familiarity with the test, and a period during which added experiences doubtless increased their ability to see abstract relationships. None of the 15 children made an error when selecting the big form in this series. Since we find the same trend in the selections of both the little and middle-size forms, the lengthened period and additional testing were doubtless influential factors in the selection of all three sizes. Six children out of nine who were given all 3 series during six months chose the big form correctly. They included a child of four years and eleven months, and one two years and seven months. Age does not seem to have been any more influential in this series than in the two previous series, except that the two children who made the greatest number of errors in all their selections were the youngest in the group. However, the child who came third in the total number of errors was the oldest in the group. Two children made all their selections for the middle size forms incorrectly. They both chose the smallest forms which were in the intermediate position when the middle size was first requested. These children were three years and four months, and four years and eleven months of age.

Summary. In Series Z, we have considered the factor of color as an influential factor in selection for relative size. We find that the results resemble closely those found in Series Y. The results from the color series give additional evidence of the greater difficulty in perception of the relation of middle size than for that of little or big. It is also shown that, in general, the greater the difference between forms, the more accurate is the choice. This is in agreement with the results of Series Y. We have also found that age, form, and the order in which the sizes were presented have probably not been determining factors in the choices.

The introduction of colored forms which might be assumed to introduce an interfering factor gives results that emphasize the early development of the concept of magnitude, though particular relations between sizes of objects, as middle size, are not equally developed at a given age.

CONCLUSION

The results from this study show that at the age of 3 years some children have developed concepts of magnitude though instability in perceptual reactions to varying relations between the sizes of objects is manifested. Inaccuracy in response to some situations does not indicate absence of a concept of size. This is indicated by the large percentage of children who make correct responses in selection of the largest object, though in another series that same object may have been the smallest. There is a perception of the relative difference in size. Correct choices of the smallest object were not so frequent as for the biggest though many children of the group were consistently correct.

The perception of the middle-size relation, in which the child must perceive that one object is smaller in relation to another object though it is correspondingly larger than the third object, is not a well developed concept at the ages studied. However, some children under five are capable of making correct responses in situations demanding the perception of intermediacy.

The extent of the differences in size influences slightly the response made. If the differences in size between objects are very small, the discrimination of the differences becomes difficult, and the perception of relative differences becomes increasingly inaccurate. With the size differences presented in this study, the three relations were perceived for all sizes though the middle-size relation was more difficult to perceive. Responses to the smaller size differences show slight increase in inaccuracy.

The tests for stability of the concept of magnitude—the color series and the presentation of a series with no difference in size of objects—substantiate the conclusion that some children develop a concept of magnitude earlier than others. Other children perceive differences in size but are not stable in perception of relative differences, under the varying conditions of presentation.

Individual differences in response do not clearly indicate definite age differences in the ability to select objects with reference to relative size. There is a trend toward less accuracy

in the younger children but some of this group excel some in the older group. Below 3 years of age there was a tendency toward making the same selection throughout the series. This would seem a failure to interpret the instructions. Preference for certain sizes or certain positions may have been influential. Control in the test procedure was not sufficient to state from the results whether the children perceived the relations. It is evident that some children 3 years of age have formed a concept of magnitude. The results point to the conclusion that the children were not influenced in their selections by the forms of the objects presented; that the sizes requested were presented in different orders did not seem to affect their choices; and also that the introduction of color in the last series did not affect the accuracy of their choice. The children's selections, then, must have been made after consideration of the sizes themselves. The conclusion that the child's ability to make perceptual judgments was a basis of his choice, seems justified from the data presented.

REFERENCES

(1) BALDWIN, B. T. and STECHER, L.: The psychology of the pre-school child. New York; D. Appleton, 1924.

(2) HAZLITT, V.: Children's thinking. British Journal of Psychology. 1930, 20.

(3) HICKS, J. A. and STEWART, F. D.: The learning of abstract concepts of size. Journal of Child Development, 1930, 1.

(4) ISAACS, SUSAN. Intellectual growth in young children. New York, Harcourt, Brace and Co., 1930.

(5) JOHNSON, BUFORD: Child psychology. Baltimore, Charles C. Thomas, 1932.

(6) OPPENHEIM, N.: The development of the child. New York, Macmillan Co., 1908.

(7) PIAGET, JEAN: Language and thought of the child. New York, Harcourt, Brace and Co., 1926.

(8) RICE, CHARLOTTE. The orientation of plane figures as a factor in their perception by children. Journal of Child Development, 1930, 1.

Inter-Relationships of Motor Abilities In Young Children

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ONE of the questions which persistently intrudes itself in the study of motor skill has to do with the possible existence of a general factor of motor ability which is to some degree independent of variations in age, sex, physical size and strength, intelligence and similar traits. Expressed somewhat differently, the question is whether or not motor abilities involving different muscle-groups and differing in apparent complexity show any tendency to vary concomitantly in the same individual when other factors, such as those noted above, are held constant.

For many reasons, the optimum time to study this question seems to be the years of early childhood, before differential practice and unequal motivation from outside sources have too far complicated the results. Although it is recognized that even among children from two to six, important differences in interests and experience unquestionably exist, nevertheless there can be no denial that whatever modification of original behavior-tendencies may have been induced thereby, these modifying influences have had a far shorter time to exert their effects when the subjects are studied in early childhood than is true in the case of adults. Childhood likewise seems to be the time when such questions as the existence of sex differences in pattern of ability is of most significance, since by tracing such differences backward to earlier and earlier ages there is greater possibility of ascertaining their origin in nature or nurture. Another question which takes on particular significance if studied during the early years before interests and habits have become too firmly set, has to do with the persistence of individual differences in specific abilities over a period of time. This is a question which has provoked much discussion and a large amount of experimental investigation in the field of intelligence measurement, but one which has scarcely been touched as far as motor skills are concerned.

With the foregoing questions in mind, the Institute of Child Welfare at the University of Minnesota undertook an investigation which was designed to throw some light on these problems. All children attending the nursery school and experimental kindergarten were given a series of brief tests of motor abilities at annual intervals. The testing schedule was so arranged that all children were tested at the period mid-way between the annual birthdays, that is, at ages $2\frac{1}{2}$, $3\frac{1}{2}$, $4\frac{1}{2}$, and $5\frac{1}{2}$. The maximum amount of variation from the defined age was one month in either direction.

In the great majority of cases, the deviation from the standard age was only a few days. Since motor abilities change so rapidly with age during the period of childhood, the importance of controlling the age factor in studies of this kind can hardly be over-estimated.

The following tests were used:

I. *Time required for walking a 25-foot line.* The apparatus for this test consisted of a 25-foot length of white paper, down the center of which had been gummed a strip of one-inch brown paper such as is used for sealing parcels. We used this in preference to the well-known "walking board" for two reasons: first, because walking boards were used as standard equipment in the nursery school which meant that the children had had a variable amount of previous experience with them, and secondly because it seemed desirable to employ a longer test than is afforded by the walking board of conventional length. While a 25-foot board is possible, it is a cumbersome bit of apparatus, especially when storage space is limited. Preliminary investigations indicated that the walking path is quite as reliable a measuring device as the walking board, although the type of motor ability which it measures is probably not identical with that measured by the walking board in which the factor of balance plays a greater part.

Our procedure in giving this test was as follows. The strip of paper was spread down a hallway at a time when this part of the building was not in use. The examiner said, "I want to see how straight you can walk. Here is a little narrow path. See if you can walk all the way down without stepping off the path even once. Watch me and see how I do it." The examiner then walked the length of the line slowly and carefully, repeating at intervals as she did so, "You see I have to be very careful. I have to watch to see just where to put my feet so I won't step off." On reaching the end of the line she said to the child, "Now let's see how well you can do it. Be sure to step right on the path every time." The examiner then took up a position at the end of the path where the child's steps could be watched accurately. The child was placed at the opposite end of the path, facing the examiner, who said, "Now see how fast you can walk all the way down the little path to me. Do it as fast as you can but be sure not to step off the path." The stop watch was started when the child took his first step and was stopped as soon as he reached the end of the line. Three trials, taken in immediate succession, were given but only the results of the second and third have been included in the results. The first trial was treated as a fore-exercise.

II. *Number of errors made in walking a 25-foot line.* Errors were counted by observation of the number of times the child stepped off the path. Although this method of counting errors is somewhat subjective, it was found that simultaneous observers agreed very closely in their count. In the majority of instances the records obtained in this way tallied exactly, and disagreements amounting to more than one error rarely occurred. Only

the number of errors made in the second and third trials have been included in our results.

III. *Finger Tapping with the Comptometer.* The procedure used was identical with that employed in an earlier study by Goodenough and Tinker (1). The child to be tested was seated before a key-drive adding machine (the comptometer). The tapping procedure was first demonstrated by the experimenter, after which a brief preliminary trial was given so that the child might "see how it works." The experimenter then said, "Now I am going to see how fast you can tap with this finger alone" —(touching index finger of right hand). "Get ready so you can start when I say, 'go.' Ready—go!" The stop watch was started simultaneously with the first tap, not at the word, "go," since young children sometimes fail to start promptly on signal. Likewise the examiner was careful to take such a position that the indicator could be read as the word "stop" was pronounced at the end of the time limit, thus minimizing the errors due to individual differences in the children's reaction-time. After the index finger of the right hand had been tried, the examiner said, "Now I am going to see which of your fingers can work fastest. Let's try this one next," touching the index finger of the left hand. Thereafter the order was as follows: Middle finger of right hand, middle finger of left hand, little finger of right hand, little finger of left hand. Short rest periods, during which the examiner chatted with the child or gave him a toy to play with, were interspersed between the trials. The time allowance was 10 seconds for each finger.

After this series, known as the unimanual series since only one hand was used at a time, had been completed, the examiner said, "Now we'll have the two hands run a race. Use these keys" (touching the two corner keys in the bottom row) "and tap just as fast as you can with both hands together." The two index fingers were tried first, then, after a rest period, the two middle fingers were tried, and then, following a second rest period, the two little fingers. This is known as the bimanual series. A separate report in which the detailed results of this test and that of test No. VI (stylus tapping), will appear in a forthcoming article (2). In the present study the total number of taps made with each finger by both methods have been summed for purposes of correlation with the other tests.

IV. *Time required to thread a series of five needles of varying size.* The apparatus used for this experiment is the needle threading test distributed by the Stoelting Company, Chicago (Cat. No. 19215). The set of five needles was placed before the child in the holder provided with the test. A short length of fine wire, the diameter of which was a trifle less than half that of the eye of the smallest needle was used in place of a thread. The examiner said, "I want to see how good you are at threading needles. Let's play that this piece of wire is a thread and see how quickly you can put it into the eye of each of these needles

in turn. Watch to see how I do it." After demonstrating the procedure, the examiner handed the wire to the child saying, "Now see how fast you can thread them." Time was taken on each needle separately, and the sum of the times on all five needles was used as the child's score. It was found better to time the needles separately, since, in spite of instruction, some of the younger children would stop to talk or to wait for further instruction after one needle had been threaded before passing on to the next. A brief rest period was taken after the series had been completed, and then a second trial was given for the purpose of determining the reliability of performance from trial to trial. A time limit of two minutes for the entire series was used.

V. *"Three-hole test." Number of thrusts with each hand in a 10-second period.* The apparatus used for this test is the well known "Three-hole test" devised by Fernald and supplied by Stoelting (Cat. No. 19307). The procedure in giving this test was similar to that used in other tests of the series. After demonstration by the examiner, the child was urged to thrust the stylus into each of the three holes in turn as rapidly as possible. A 10-second trial with each hand was given, followed by a rest period after which the test was repeated in the same manner as before. The score is the sum of the number of thrusts with the two hands on the two trials combined as recorded by an electrical counter.

VI. *Tapping with stylus on metal plate with electrical counter.* As with the finger tapping, the procedure used with this test is identical with that in the previous study by Goodenough and Tinker (1). The child was instructed as to the manner of holding the stylus and the position of the arm and hand. Verbal instruction was followed by demonstration by the examiner, and by a short fore-exercise in which any departures from the standard procedure were noted and corrected. Tapping was done for a period of ten seconds with each hand, after which a rest period was given and the test repeated as before.

VII. *Simple reaction time.* The procedure and the detailed results for the reaction-time experiment have been reported elsewhere (3). The apparatus used was the Miles Reaction Board (4). Twenty reactions, ten with each hand, were obtained for all cases, and the median time taken as the score for an individual child.

With the exception of the reaction time test, which was taken on a separate occasion, all tests were given at a single sitting. The total time required did not exceed 20 minutes. The reaction time test, which was given on a separate day, usually required about 10 minutes at most. Motivation was not difficult to secure or to maintain, since the sittings were relatively short and the material used was varied and interesting to the children. Moreover, since all the children were attending the experimental nursery school and kindergarten of the University of Minnesota, they were well habituated to the laboratory procedure and surroundings. The tests were given by research assistants in the Institute whom the children knew and with

whom they felt completely at ease. Each assistant who took part in the experiment was given a period of preliminary training in the manner of giving the tests to make sure that a constant procedure would be followed by all. Only the records of those children who took all the tests and who evinced a high level of coöperation throughout the entire series have been included in the results.

Table 1 shows the means and standard deviations of scores on the motor tests for each of the four age-groups studied. Except for the reaction-time test, the values given in this table are the sums of the scores on the two trials given. The reaction-time values represent the means of the individual scores at each age. An individual score, it will be recalled, is the median of 20 reactions made in immediate succession and expressed in sigma units.

TABLE 1

Means and standard deviations of scores on motor tests by age

AGE	NUMBER OF CASES	WALKING PATH				FINGER TAPPING		NEEDLE THREADING		THREE-HOLE TEST		STYLUS TAPPING		SIMPLE REACTION-TIME	
		Time		Errors											
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
2½	20	22.7	5.4	23.7	10.6			122.4	113.2			103.5	26.4		
3½	24	31.5	18.8	13.1	8.5	163.5	50.2	59.2	50.9	36.7	9.9	136.1	19.2	67.6	23.8
4½	30	24.1	11.8	6.0	4.7	238.8	52.1	50.5	28.4	46.2	10.6	154.0	36.3	48.2	12.7
5½	80	21.7	9.4	3.1	2.3	291.1	51.5	32.8	17.4	56.2	11.1	151.5	27.3	45.0	15.1

As was to be expected, there is a general improvement in the scores earned on all tests with advancing age. This is represented either by a decrease in the length of time required to perform a test, or by an increase in the amount accomplished during a set time. The only exceptions to this rule are to be found in the length of time required for the walking path by the children of two-and-a-half years, and in stylus tapping by the children of five-and-a-half years. The first is probably to be ascribed to a difference in the kind of performance most typical of the younger children as compared to that of the older groups. In general the younger children tended to be relatively oblivious to errors; or perhaps the explanation is that they did not know how to avoid making errors. They watched the line and apparently tried to step on it each time, but few of them seemed to have grasped the idea that by retarding their speed they could get better control over the exact placing of their feet. The average time for this age-group is shorter than that for either of the two age-groups following it, and is only slightly longer than that for the children of five-and-a-half years. Practically all the children at this age behaved in a very uniform fashion, which is indicated by the small size of the standard deviation. This indicates that in all probability we are dealing with a true characteristic of the normal two year old child, and that the results obtained can not

safely be ascribed to a fluctuation in sampling.

The second break in the curve of improvement with age is to be seen in the average score in stylus tapping when the children of five-and-a-half years are compared with those of four-and-a-half. In this case, however, chance fluctuation seems to be the more probable explanation. Examination of the distribution of scores and comparison with those obtained in the previous study by Goodenough and Tinker makes it appear likely that the average obtained for the children of four-and-a-half is slightly higher than would be obtained from other samplings drawn from the same population, while that for the children of five-and-a-half is somewhat too low.

The coefficients of variability do not change greatly with age, although a slight decrease with advancing age is apparent for certain tests. In general, however, the ratio of the standard deviations to the mean is fairly constant. Some writers have been inclined to look upon the coefficient of variability as a measure of the reliability of the tests. While this is a somewhat questionable assumption, it may be noted that errors on the walking path and time required for the needle threading test show the highest variability coefficients, while the two tapping tests rank lowest in this respect.

The figures presented in table 1 are for the sexes combined since separate treatment of the findings for the boys and girls showed only very small differences between the means with almost complete overlapping of the distributions. The small differences that appeared may be summarized as follows: In the reaction-time test the boys surpassed the girls at all ages but the differences amounted to only two or three sigma. The girls were slightly superior to the boys in needle threading and in the three-hole test, both of which involve fine manual coördination A possible superiority of the boys on both tapping tests was indicated but not reliably established.

Table 2 shows the reliability coefficients for the several tests by ages separately. In interpreting these figures it should be recalled that the range of ages within a given age-class is very short, and that the coefficients herein presented are therefore but little affected by age heterogeneity. With the exception of the number of errors made on the walking path by the children of five-and-a-half years, and the needle threading test for the children of four-and-a-half or older, the correlations are encouragingly high when the short time-allowance for the various tests is taken into account. The lowered reliability in the three instances mentioned is in large part due to the fact that for children of these ages the test has become too easy to be a significant measure of individual differences in ability.

A note with regard to the probable errors given in the last column of table 2 may be desirable. The ordinary formula for the probable error of a correlation coefficient does not take account of the fact that, as the correlations approach unity, the distribution of the probable errors becomes more and more skewed. In other words, the probability that in other samples drawn from the same popula-

tion the obtained coefficients would diverge from those obtained in the present investigation by the amount of one, two, or three probable errors in the direction of zero is much greater than the probability of a corresponding divergence in the opposite direction. Two methods have been proposed to compensate for this factor,—the substitution of Fisher's z function for the coefficient of correlation and the upon the existence of some degree of relationship between the two variables considered. The reporting of the probable error of a correlation of zero obtained from a given number of cases is a procedure that has been frequently employed in biometrics but has been less commonly used in psychological or educational statistics.

Tables 3 to 9 show the intercorrelations of the various tests with each

TABLE 2

*Reliability coefficients of motor tests for single age-groups**

AGE	N	WALKING PATH		FINGER TAPPING†	NEEDLE THREADING	THREE-HOLE TEST	STYLUS TAPPING	SIMPLE REACTION	P.E. WHEN $r = .00$‡
		Time	Errors						
		r	r	r	r	r	r	r	
2½	20	.86	.94		.92		.90		.15
3½	24	.90	.92	.84	.90	.87	.82	.86	.14
4½	30	.83	.90	.90	.65	.87	.85	.81	.12
5½	80	.84	.64	.77	.53	.85	.92	.92	.07

* All coefficients are calculated by the Pearson product-moment method and, with the exception of the finger tapping, they are based on the correlation between first and second trials given at the same sitting and corrected by the Spearman-Brown prophecy formula.

† The reliability coefficient of the finger tapping is based upon the sum of the scores for three fingers of each hand in unimanual tapping vs. the corresponding sum for bimanual tapping. Previous investigations have shown that this correlation is likely to be somewhat lower than the true reliability coefficient based upon scores obtained by the repetition of the test when the same method is used for both trials.

‡ Computed by formula: $\text{P.E.}_r = .6745 \frac{1 - r^2}{\sqrt{N - 1}}$.

simpler procedure of reporting, in all cases, the probable error of a correlation of zero obtained from the same number of cases. Only when r equals zero will the probable errors of r be distributed symmetrically in both directions. The probable errors given in table 2 indicate the likelihood of obtaining a correlation of the magnitudes reported if the true correlation were zero. That is, they indicate the amount of reliance that can be placed other at successive ages. In general, these intercorrelations are low and, if considered separately, would merit little consideration, but a comparison of the directions of the relationships at various ages suggests certain general trends. It was therefore thought worth while to make a factor analysis of the results according to Thurstone's method (5, 6, 7). Application of this technique suggests the existence of at least one common factor running

through all the tests and indicates also the probability of one or more group factors entering into several of them. The loadings for these factors at each of three age-levels are shown in tables 10 and 11.

TABLE 3

*Correlation of speed on walking path with other variables at successive ages**

AGE	N	WALKING PATH, FEWNESS OF ERRORS	FINGER TAPPING	SPEED, NEEDLE THREADING	THREE-HOLE TEST	STYLUS TAPPING	SIMPLE REACTION SPEED	P.E. WHEN r = .00
		r	r	r	r	r	r	
2½	20	+.24		+.19		−.04		.15
3½	24	−.01	−.21	−.22	+.18	−.27	−.34	.14
4½	30	+.18	+.01	−.20	+.32	−.10	+.15	.12
5½	80	−.02	+.09	−.18	.00	−.11	+.14	.07

* In this and all succeeding tables, the scores have been so arranged that a positive sign preceding a correlation coefficient indicates correspondence in the direction of improvement while a negative sign signifies that as one variable showed improvement the other showed a decrement. Thus, since a shorter time for the walking-path test is a mark of improvement as is also a greater number of thrusts on the three-hole test. The positive correlations reported in Table 3 with the three-hole test signify that as time decreased (or speed increased) the number of thrusts increased.

TABLE 4

Correlation of fewness of errors on walking path with other variables at successive ages

AGE	N	WALKING PATH, SPEED	FINGER TAPPING	SPEED, NEEDLE THREADING	THREE-HOLE TEST	STYLUS TAPPING	SIMPLE REACTION SPEED	P.E. WHEN r = .00
		r	r	r	r	r	r	
2½	20	+.24		+.37		+.53		.15
3½	24	−.01	−.27	−.11	+.31	−.08	+.13	.14
4½	30	−.18	−.19	+.26	+.53	+.09	+.24	.12
5½	80	−.02	+.08	+.21	+.20	+.26	+.21	.07

TABLE 5

Correlation of scores on finger tapping with other variables at successive ages

AGE	N	WALKING PATH, SPEED	WALKING PATH, FEWNESS OF ERRORS	SPEED, NEEDLE THREADING	THREE-HOLE TEST	STYLUS TAPPING	SIMPLE REACTION SPEED	P.E. WHEN r = .00
		r	r	r	r	r	r	
3½	24	−.21	−.27	+.26	+.54	+.46	+.15	.14
4½	30	+.01	−.19	+.34	+.51	+.40	+.17	.12
5½	80	+.09	+.08	+.22	+.21	+.17	+.32	.07

In view of the small number of cases at the two lower ages and the conse-

TABLE 6

Correlation of speed of needle threading with other variables at successive ages

AGE	N	WALKING PATH, SPEED	WALKING PATH, FEWNESS OF ERRORS	FINGER TAPPING	THREE-HOLE TEST	STYLUS TAPPING	SIMPLE REACTION SPEED	P.E. WHEN r = .00
		r	r	r	r	r	r	
2½	20	+.19	+.37			+.27		.15
3½	24	−.22	−.11	+.26	+.30	+.42	+.16	.14
4½	30	−.20	+.26	+.34	+.39	−.03	−.02	.12
5½	80	−.18	+.21	+.22	+.38	−.03	−.03	.07

TABLE 7

Correlation of scores on the three hole test with other variables at successive ages

AGE	N	WALKING PATH, SPEED	WALKING PATH, FEWNESS OF ERRORS	FINGER TAPPING	SPEED, NEEDLE THREADING	STYLUS TAPPING	SIMPLE REACTION SPEED	P.E. WHEN r = .00
		r	r	r	r	r	r	
3½	24	+.18	+.31	+.54	+.30	+.08	+.14	.14
4½	30	+.32	+.53	+.51	+.39	+.05	+.18	.12
5½	80	.00	+.20	+.21	+.38	+.23	−.04	.07

TABLE 8

Correlation of scores on stylus tapping with other variables at successive ages

AGE	N	WALKING PATH, SPEED	WALKING PATH, FEWNESS OF ERRORS	FINGER TAPPING	SPEED, NEEDLE THREADING	THREE-HOLE TEST	SIMPLE REACTION SPEED	P.E. WHEN r = .00
		r	r	r	r	r	r	
2½	20	−.04	+.53		+.27			.15
3½	24	−.27	−.08	+.46	+.42	+.08	−.08	.14
4½	30	−.10	+.09	+.40	−.03	+.05	+.22	.12
5½	80	−.11	+.26	+.17	−.03	+.23	+.11	.07

TABLE 9

Correlation of simple reaction speed with other variables at successive ages

AGE	N	WALKING PATH, SPEED	WALKING PATH, FEWNESS OF ERRORS	FINGER TAPPING	SPEED, NEEDLE THREADING	THREE-HOLE TEST	STYLUS TAPPING	P.E. WHEN r = .00
		r	r	r	r	r	r	
3½	24	−.34	+.13	+.15	+.16	+.14	−.08	.14
4½	30	+.15	+.24	+.17	−.02	+.18	+.22	.12
5½	80	+.14	+.21	+.32	−.03	−.04	+.11	.07

quent high probable errors of the intercorrelations upon which the factor analysis is based, exact agreement of the obtained loadings from one age to another could not be expected. There is reason to think, moreover, that the true loadings as obtained from populations of infinite size would change somewhat with advancing age. It is highly improbable that the organization of abilities in children of three years corresponds exactly with that of the same children at the age of five. More in accordance with our present knowledge of child development is the viewpoint that as the child grows, different types of ability come into prominence which, in their turn, will give place to others as growth proceeds. In other words, not only the absolute level of ability but its most typical pattern undergoes a series of progressive changes with age. Nevertheless, we should not expect to find that these changes occur so rapidly in the child of preschool age that the pattern becomes kaleidoscopic. Some degree of resemblance in the factors underlying the relationships of one type of performance to another and hence some degree of similarity in the factor loadings for a given test at

TABLE 10

Factor loadings for the several tests

Factor I

	AGE		
	3½	4½	5½
Speed, walking path	−.384	+.105	−.088
Fewness of errors, walking path	−.104	+.422	+.385
Speed, finger tapping	+.786	+.578	+.380
Speed, needle threading	+.611	+.372	+.498
Three-hole test	+.359	+.828	+.711
Stylus tapping, speed	+.546	+.340	+.330
Reaction-speed	+.298	+.389	+.192

TABLE 11

Factor loadings for the several tests

Factor II

	AGE		
	3½	4½	5½
Speed, walking path	−.278	−.087	−.217
Fewness of errors, walking path	−.314	+.763	−.200
Speed, finger tapping	+.045	−.466	−.308
Speed, needle threading	−.031	+.269	+.308
Three hole test	+.796	+.162	+.223
Stylus tapping	−.300	−.330	−.263
Reaction speed	+.183	−.016	+.514

successive levels of performance is logically to be expected. It is quite possible, for example, that the gain in the performance of a complex skill from age two to age three may be largely due to improvement in Factor I, and that later gains are dependent in increasing degree upon Factor II, while still later Factor III comes in as the chief determinant of the higher levels of skill. However, such changes in factor-pattern as well as the changes in total performance on the task in question are, in all probability, gradual rather than saltatory. If this point of view is correct, it is logical to expect that the factor loadings for a series of tests given at annual intervals will change somewhat from one year to the next but that some relationship, though not necessarily a perfect one, will be maintained. Since, as far as the writers are aware, no one has previously subjected the factor analysis method to the test of comparing the loadings obtained for the same tests when applied to children of successive age-levels, it seems worth while to submit our findings in spite of the small number of cases at the two lower ages.

It will be seen from table 10 that there is a fair amount of consistency in the loadings for the first factor at all three ages. While the nature of the factors brought out in a factor analysis is of necessity a matter of logical inference rather than of statistical objectivity, the distribution of the loadings from one test to another suggests that the common factor is something analogous to general motor maturity. Since chronological age has been experimentally controlled within each group, individual differences in respect to this factor must be ascribed to a more rapid rate of motor development in some children than in others. The negative loading of the walking path test with this factor at the age of three is in accordance with the observation that the early stages of progress in this skill are marked by an increase, rather than a decrease, in the time required to perform the task. Among the children of four and five years, variations in time become of relatively little importance as indications of motor maturity, but are probably more nearly related to temperamental characteristics. The significant thing at these later ages is the number of errors made. The factor analysis is thus in accordance with the conclusions which might be directly arrived at by observation of children of different ages when performing the task, viz.: that over the age range included in this experiment, maturity of performance on the walking path is manifested first in a decreased speed of performance and later by a decrease in the number of errors.

The relative significance of the first factor shows a tendency to decrease with age in both tapping tests, the needle threading test, and the reaction-time test. This suggests that performance on these tasks is more definitely dependent on general motor maturity at the early ages than at the later ages, and that as age advances, specific factors play an increasingly greater part. This is equivalent to saying that the maturation curve for these functions is negatively accelerated. That this is true for the tapping test at least has been shown else-

where (2). The three-hole test, on the contrary, shows a maximum loading with Factor I at the age of four-and-a-half. The comparatively smaller loading at the age of three may reflect the influence of temperamental characteristics among the younger children, a number of whom found this test difficult and uninteresting and who therefore may have been less inclined to put forth their best efforts. While the slight falling off in the first factor loading for this test at the age of five may be a fluctuation of sampling, it is very possible that it marks the beginning of a negatively accelerated rate of maturation, comparable to that shown in the four tests previously mentioned.

Examination of the second factor loadings for the different tests suggests that this factor may best be described as attentiveness or carefulness. Moreover, since a number of the loadings for this factor approximate zero, it would appear to be more limited in its functioning than is the first factor. The second factor shows a small negative relationship to speed on the walking path at all ages which is in line with our tentative interpretation that carefulness or attentiveness is involved, as is also the high positive loading with fewness of errors at the age of four. It appears to exert a negative effect upon speed of tapping which accords with our observation that children who were over-meticulous about their manner of tapping were less likely to attain a high degree of speed. The positive second factor loading of the three-hole test and the needle threading test where close attention to the task in hand is needed is also in accordance with this hypothesis. Speed of reaction also shows a fairly high loading with this factor among the five year olds, but very little relationship to it at the earlier ages. The latter fact may be a fluctuation of sampling since the number of cases is small. On the whole, our interpretation of this factor seems to fit in with the test loadings reasonably well except for the negative loadings with fewness of errors on the walking path at ages three and five. These loadings are not large, however, and may be chance fluctuations from zero.

The analysis was carried out one step further to include a third factor, but the loadings were small and showed so little consistency from one age to another that it seemed probable that they were chiefly determined by chance. Had the number of cases at each age been large enough to reduce the probable errors of the intercorrelations to a neglible amount, it is likely that other factors could have been located.

In spite of our limited sampling we nevertheless feel that the data are worth presenting since they suggest the possibility of utilizing the multiple factor technique for arriving at a quantitative analysis of the qualitative changes in pattern of ability that are characteristic of the growth-process.

REFERENCES

(1) GOODENOUGH, F. L., and TINKER, M. A.: A comparative study of several methods of measuring speed of tapping in children and adults. Pedagogical Seminary and Journal of Genetic Psychology, 1930, **38**, 146–160.

(2) GOODENOUGH, F. L.: A further study of speed of tapping in early childhood. To appear in a forthcoming number of the Journal of Applied Psychology.

(3) GOODENOUGH, F. L.: The development of the reactive process from early childhood to maturity. To appear in a forthcoming number of the Journal of Experimental Psychology.

(4) MILES, W. R.: Correlations of reaction and coordination speed with age in adults. American Journal of Psychology, 1931, **43**, 377–391.

(5) THURSTONE, L. L.: Multiple factor analysis. Psychological Review, 1931, **38**, 406–427.

(6) THURSTONE, L. L.: A simplified multiple factor method and an outline of the computations. Copyright, 1933 by L. L. Thurstone. Distributed by the University of Chicago Bookstore, Chicago, Ill. Pp. 25.

(7) THURSTONE, L. L.: The vectors of mind. Psychological Review, 1934, **41**, 1–32.

Mental and Social Maturity in Relation to Certain Indicators of the Degree of Juvenile Delinquency

MERVIN A. DUREA

I

SCIENTIFIC evidence has tended to establish that intelligence and social factors each have an appreciable relationship to delinquent behavior. Research, such as that of Ackerson (1), denotes that in certain definite respects mental development is not without differential significance in the problem of juvenile misconduct. Reckless and Smith (6) point out the variety of angles from which the social backgrounds of delinquents have been studied effectively. In line with investigations of the relationship of intelligence and delinquency on the one hand and social factors and delinquency on the other two desiderata merit attention. First, most studies whether of intelligence or social factors have considered juvenile delinquency as a general form of behavior without reference to the fact that it is variable in its manifestations. Slawson (7) has departed from the rule by estimating the degree of delinquency in terms of the number of arrests and severity of penalty for each offense. Second, while considerable is known concerning the effect of family size, home relationships, community conditions, home conditions, and other such social elements on the problems of delinquency, the question of social development of the individual delinquent has received little or no consideration, due probably to a lack of adequate techniques. Recently, however, with the advent of Furfey's (4) work the possibility of measuring the social development of juvenile offenders has presented itself.

From the point of view of the foregoing considerations the present study is concerned with the following:

(a) the pointing out of criteria which appear to be "indicators" of the degree of juvenile delinquency;

(b) the determination of the relationship of mental and social maturity to these indicators.

II

In this investigation the cases of 365 delinquent boys from the Boys' Industrial School[1] located at Lancaster, Ohio, were used. All subjects were of the white race. Aside from racial grouping no attempt was made at selection for factors such as intelligence and life age. It is probable that the group represents a fairly representa-

[1] Subjects were obtained through the coöperation of Mr. A. R. Harsh, Superintendent and Mr. Eric Bell, Psychologist.

tive cross-section of delinquent boys in general.

On each subject an intelligence rating was obtained by means of the National Intelligence Test, Scale A. Developmental ratings were secured by the Furfey Scale for Developmental Age, employing the original form (4). Results from the application of these two techniques were studied in terms of the Intelligence Quotient (IQ) in the case of the former and Developmental Quotient (DQ) in the case of the latter.

As indicators of the seriousness of delinquent behavior three criteria were used:

(a) *Frequency* (F)—the total number of times a given subject has appeared in Juvenile Court.

(b) *Scale Values* (SV)—an application of the writer's (3) scaling method to the offenses committed by a given subject. The different forms of offense were listed, a weighted value was assigned to each and these values were totaled.

(c) *Number of Offenses* (NO)—the total number of different forms of offense which a given subject has committed.

A gist of a typical case will clarify the method:

Case R. N. Subject is 16 years 5 months of age. He has been delinquent for over four years, having first appeared in Juvenile Court when 12 years of age. He has appeared in Court on three occasions. Offenses committed include truancy from home, burglary, and stealing. Burglarized two stores, stole $35 and food, boarded away from home with the stolen money, truant from home for a long period. Mental age on the National Intelligence Test was 16 years 6 months, Intelligence Quotient 103. Developmental age by the Furfey Scale 18 years 1 month, Developmental Quotient 113.

The following are the indicators of the degree of juvenile delinquency in this case: F = 3, SV = 86, and NO = 3. Scale Value was obtained from the sum of the differential weightings assigned to incorrigibility, burglary, and stealing, the weights being 20, 39, and 27, respectively.[2] In deriving SV's and NO's no account has been taken of repeated offenses of the same general type. Although a subject may have committed two or more delinquent acts classifiable as incorrigibility only the *form* and not the *specific act itself* has been considered. It has been assumed that in so far as offenses committed by a given subject are indicative of the seriousness of his delinquent behavior, the general form rather than the specific act expressive of this form is the more significant for computing SV's and NO's. Thus, for example, though the subject cited (Case R.N.) had two specific acts of burglary recorded against him, only burglary as the form of delinquency has been taken into account.

III

It has been indicated that Intelligence Quotients have been used to show the relative standing of subjects in mental ability and Developmental Quotients[3] their rating by the develop-

[2] For a full account of the method for classifying delinquencies under fourteen heads with differential scale values for each form of offense see the writer's article (3).

[3] Developmental Quotient = $\frac{\text{Developmental Age}}{\text{Life Age}} \times 100$.

mental scale. By following this procedure the factor of life age has been controlled. In those instances in which life ages exceeded 16 years the 16-year denominator has been employed in calculating both Intelligence Quotients and Developmental Quotients. Adoption of the 16-year standard was, of course, arbitrary, especially in computing Developmental Quotients. Recent work of Furfey (5), however, suggests the possibility of an upper-limit of 16 years in relation to normal social development. The 16-year standard appeared to be justified in calculating Intelligence Quotients from the National Intelligence Test since there is some question as to whether this instrument is psychometrically equivalent to the Stanford-Binet or other intelligence scales in connection with which a 14-year upper-limit is used at times.

TABLE 1

Frequency distribution of Intelligence Quotients

Intelligence Quotients

	CLASS INTERVAL								TOTAL
	50–59	60–69	70–79	80–89	90–99	100–109	110–119	120–129	
Number of Cases.....	2	30	97	98	62	64	11	1	365

Table 1 shows a frequency distribution of Intelligence Quotients based on the cases of 365 delinquent boys. As will be noted, the distribution approximates a normal probability curve. The mean Intelligence Quotient is 86.8, the AD 11.1.

The amount of mental retardation evidenced by the present group of delinquents compares favorably with that which has been found by other investigators. Burt (2) states that the "average mental ratio of the juvenile offender proves to be about 89 per cent." Slawson (7), utilizing both a 16-year and 14-year upper-limit, found Stanford-Binet Intelligence Quotients averaging 76.4 in the former case and 87.7 in the latter on a group of boys from the New York House of Refuge. It is probable that the mean IQ based on an upper-limit of 14 years is a more accurate measure of the mental status of delinquents since the Stanford-Binet was used. Ackerson (1) estimates the average Intelligence Quotient of both sexes to be between 75 and 80. Apparently two facts are implied by a study of the Intelligence Quotients of juvenile offenders: (a) as a group they are mentally retarded; and (b) their typical Intelligence Quotient is in the neighborhood of 80 to 85.

Table 2 shows a frequency distribution of DQ's, the general tendency of which is likewise normal but with considerably more spread than in the distribution of Intelligence Quotients. The mean Developmental Quotient is 96.4, the AD 16.8. In so far as a Developmental Quotient of about 100 represents average social maturity, juvenile delinquents conform closely

to this standard. As a group, therefore, they are more mature socially than mentally since in comparison with an Intelligence Quotient of 100 the present group as well as others show a significant amount of retardation.

Referring again to indicators of the degree of delinquent behavior, Tables 3, 4, and 5 present frequency distributions of F, SV, and NO, respectively.

TABLE 2

Frequency distribution of Developmental Quotients

Developmental Quotient

	CLASS INTERVAL											TOTAL
	40–49	50–59	60–69	70–79	80–89	90–99	100–109	110–119	120–129	130–139	140–149	150–159	
Number of Cases.....	1	9	25	52	58	58	63	53	31	8	6	1	365

TABLE 3

Frequency distribution of F

Frequency of Court Appearance

	CLASS INTERVAL										TOTAL
	1	2	3	4	5	6	7	8	9	10 or more	
Number of Cases.....	29	57	75	42	39	34	22	11	19	37	365

TABLE 4

Frequency distribution of SV

Scale Values

	CLASS INTERVAL														TOTAL
	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99	100–109	110–119	120–129	130–139	140–149 or more	
Number of Cases...	2	9	28	31	44	41	31	51	50	15	28	16	8	11	365

TABLE 5

Frequency distribution of NO

Number of offenses

	CLASS INTERVAL						TOTAL
	1	2	3	4	5	6	
Number of Cases.....	27	90	113	90	37	8	365

The mean of the distribution of F is 4.7, the AD 2.3. In general the measures are positively skewed.

The mean SV is 78.3, the average deviation of the array 24.8. Although somewhat irregular the distribution tends toward that of a normal frequency surface.

The mean NO is 3.1, the AD .94. It is noticeable that there is marked concentration of the cases. For example, more than 80 per cent of the

subjects fall within the class intervals 2, 3, and 4.

To point out the relationship between mental and social maturity and indicators of the extent of juvenile delinquency, two sets of tables have been constructed. Tables 6A, 6B, and 6C show, respectively, average Intelligence Quotients and Developmental Quotients for varying frequencies of appearance in Juvenile Court (F); for varying scale values (SV); and for differing numbers of offenses (NO). Tables 7A and 7B indicate, respectively, averages for F, SV, and NO in terms of different Intelligence Quotients and Developmental Quotients. The amount of deviation of each average from the mean of the distribution of the variable in question is shown in columns paralleling each series of averages and headed "Deviation." In interpreting relationships in the present connection a tenable hypothesis would seem to be that any considerable or marked divergence from the central tendency (mean) of a distribution would denote a tendency to relationship. For example, the mean Intelligence Quotient of 365 subjects as shown in Table 1 is 86.8. This may be regarded as a sort of *norm* with respect to which the series of mean IQ's in the following tables is compared. Any radical positive or negative departure from this norm would suggest relationship. The other series of means are interpreted in a similar manner.

An inspection of the foregoing three tables reveals little or nothing in the way of a tendency to relationship. It is obvious that both the Intelligence Quotients and Developmental Quotients are of comparative insignificance as differentiae of the variations occurring in the indicators, F, SV, and NO. With minor exceptions the series of mean Intelligence Quotients and mean Developmental Quotients cluster closely about the respective means of the distributions of these two measures. This is shown by the consistently small deviations and the averages of each column of deviations.

TABLE 6A

Relationship between frequency of court appearance and IQ and DQ

F	MEAN IQ	DEVIATION	MEAN DQ	DEVIATION
1	83.6	−3.2	97.4	+1.0
2	87.5	+.7	93.4	−3.0
3	88.5	+1.7	99.4	+3.0
4	86.0	−.8	93.8	−2.6
5	87.6	+.8	95.5	−.9
6	88.5	+1.7	96.2	−.2
7	87.3	+.5	97.3	+.9
8	85.9	−.9	105.0	+8.6
9	86.6	−.2	104.5	+8.1
10 or more	83.4	−3.4	91.2	−5.2
Average ...	.....	1.39		3.35

N.B.: In computing averages for "Deviations" columns in the above and subsequent tables no account is taken of signs. The averages are not "average deviations" in the technical sense.

Based on the present analysis, if a given subject is moderate, average, or extreme in delinquent behavior, as estimated by the standards of seriousness herein employed, he is likely *on the average* to conform closely to the mean of the delinquent group in mental and social maturity.

When, as shown in Tables 7A and 7B, the means for F, SV, and NO are computed for varying levels of Intelli-

gence Quotients and Developmental Quotients the findings are substantially the same as have been mentioned previously, namely, lack of relationship between mental and social maturity and indicators of the degree of juvenile delinquency. Any divergence of the series of means for F, SV, and NO from the means of their respective distributions is for the most

TABLE 6B

Relationship between scale values and IQ and DQ

SV	MEAN IQ	DEVIATION	MEAN DQ	DEVIATION
10–19	*		*	
20–29	78.6	−8.2	93.2	−3.2
30–39	86.4	−.4	94.3	−2.1
40–49	89.8	+3.0	91.1	−5.3
50–59	83.9	−2.9	95.0	−1.4
60–69	90.6	+3.8	99.4	+3.0
70–79	82.4	−4.4	92.1	−4.3
80–89	91.3	+4.5	100.0	+3.6
90–99	86.2	−.6	95.6	−.8
100–109	90.3	+3.5	101.7	+5.3
110–119	82.9	−3.9	97.1	+.7
120–129	85.6	−1.2	97.5	+1.1
130–139	82.5	−4.3	101.3	+4.9
140–149 or more	88.6	+1.8	99.5	+3.1
Average	.....	3.27		2.98

* Small number of cases in class interval 10–19 grouped with those in adjacent class interval 20–29.

TABLE 6C

Relationship between number of offenses and IQ and DQ

NO	MEAN IQ	DEVIATION	MEAN DQ	DEVIATION
1	84.6	−2.2	96.5	+.1
2	88.2	+1.4	94.8	−1.6
3	86.7	−.1	96.0	−.4
4	86.7	−.1	98.6	+2.2
5	85.5	−1.3	96.1	−.3
6	86.3	−.5	98.8	+2.4
Average	.....	.93		1.17

TABLE 7A

Relationship between IQ and F, SV, and NO

IQ	MEAN F	DEVIATION	MEAN SV	DEVIATION	MEAN NO	DEVIATION
50–59	*		*		*	
60–69	4.3	−.4	80.6	+2.3	3.3	+.2
70–79	5.1	+.4	78.1	−.2	3.1	.0
80–89	4.5	−.2	75.6	−2.7	3.0	−.1
90–99	5.0	+.3	83.1	+4.8	3.4	+.3
100–109	4.4	−.3	77.8	−.5	3.0	−.1
110–119	4.1	−.6	76.7	−1.6	3.0	−.1
120–129	**		**		**	
Average	.....	.72		2.02		.13

* Small number of cases in class interval 50–59 grouped with those in adjacent class interval 60–69.

** Small number of cases in class interval 120–129 grouped with those in adjacent class interval 110–119.

TABLE 7B

Relationship between DQ and F, SV, and NO

DQ	MEAN F	DEVIATION	MEAN SV	DEVIATION	MEAN NO	DEVIATION
40–49	*		*		*	
50–59	3.7	−1.0	72.0	−6.3	2.7	−.4
60–69	4.0	−.7	71.0	−7.3	3.0	−.1
70–79	5.3	+.6	78.5	+.2	3.3	+.2
80–89	4.9	+.2	75.3	−3.0	3.0	−.1
90–99	4.9	+.2	82.4	+4.1	3.3	+.2
100–109	4.6	−.1	79.0	+.7	3.0	−.1
110–119	4.6	−.1	74.4	−3.9	2.9	−.2
120–129	4.2	−.5	87.3	+9.0	3.3	+.2
130–139	4.3	−.4	75.0	−3.3	3.1	.0
140–149	6.3	−1.6	95.0	+16.7	3.9	+.8
150–159	**		**		**	
Average	.....	.54		5.45		.23

* Small number of cases in class interval 40–49 grouped with those in adjacent class interval 50–59.

** Small number of cases in class interval 150–159 grouped with those in adjacent class interval 140–149.

part small. In brief, with increasing or decreasing intelligence or social maturity practically no clue is given as to whether or not a given individual is a major or minor offender.

IV

From this study the following general conclusions appear to be warranted:

1. As evidenced by the Intelligence Quotient the present group of delinquents is mentally retarded, the amount of retardation being consistent with findings by other investigators.

2. In terms of Developmental Quotient the group shows a higher average level of social than mental maturity.

3. Three indicators of the degree of juvenile delinquency have been proposed, namely, frequency of appearance in Juvenile Court (F), the sum of differential weights assigned to different types of offense (SV), and number of offenses committed (NO).

4. When a series of mean Intelligence Quotients and Developmental Quotients are computed for variations in F, SV, and NO, little or no relationship is ascertained.

5. When a series of means are computed for F, SV, and NO for variations in Intelligence Quotient and Developmental Quotient no appreciable relationship is observable.

6. In general, it may be stated, that mental and social maturity bear an insignificant relationship to indicators of the degree of delinquent behavior.

REFERENCES

(1) ACKERSON, L.: Children's behavior problems, Chicago, University of Chicago Press, 1931, 121–131; 249–255; 3–26.

(2) BURT, C.: The young delinquent, New York, Appleton, 1925, 279–334.

(3) DUREA, M. A.: An experimental study of attitudes toward juvenile delinquency, Jr. Appl. Psych., 1933, 17, 522–534.

(4) FURFEY, P. H.: The measurement of developmental age, Washington, Catholic Education Press, 1928, 1–40 (Catholic University of America Educational Research Bulletins, 2).

(5) FURFEY, P. H.: A revised scale for measuring developmental age in boys, Child Development, 1931, 2, 102–114.

(6) RECKLESS, W. C., AND SMITH, M.: Juvenile delinquency, New York, McGraw-Hill, 1932, 117–159.

(7) SLAWSON, J.: The delinquent boy, Boston, Badger, 1926, 169–191; 23–53.

Brief Reports

A Report of a Case of Inverted Writing and Drawing

WITHOUT attempting to theorize or draw any conclusions the writer would like to report a case of inverted writing and drawing. The child in question, whom we shall call Arthur, lives in Jefferson County, Kentucky between twelve and fifteen miles from the heart of Louisville. He is six years and ten months of age, chronologically. He tests on the Stanford Revision of the Binet-Simon Tests 78 months which gives him an Intelligence Quotient of .95. This Intelligence Quotient is probably somewhat low because of his lack of opportunity to learn. The child seems to be about average in his personality traits. His educational achievement, his emotional reactions, and his social behavior are all average or better. He is decidedly above the average of his own group.

The locality in which Arthur has lived is a very rough, hilly, and nonproductive agriculture section. Many of the people are engaged in moonshining and bootlegging. As a whole, they are very backward and densely ignorant. Though they live but a few miles from a large city, there are children in the grades who have never seen electric lights.

The family, which consists of the father, the mother, and five boys, is a typical mountaineer family. There are two boys older than Arthur, one twelve and the other nine, and two younger. The parents are in the early thirties. The father, who is now working on the CWA relief work, has been arrested at least twice for trafficking in illicit liquor. The parents attended a one room country school and have acquired an education equivalent to about six grades. The neighborhood now has a consolidated school under the county system.

Prior to entering school in September, 1934 Arthur had had no training in reading and practically none in writing. The only reading which the boy had heard was his mother reading occasionally from a newspaper and the oldest brother getting his lessons. Arthur had scribbled a little on a slate which hung on the wall but had made no attempt to write. He had practiced a little in copying numbers placed on the slate by the oldest brother. These were copied bottom-side up from the start. However, the boy was given very little attention in this direction before entering school. The teacher testifies that the boy had practically no skill in either writing or drawing when entering school.

Arthur has made normal progress in all of his school activities and is above the average of his own group. It was a number of days after Arthur entered school before the teacher discovered his peculiarity, of which he himself

was unaware. As soon as his attention was called to his peculiarity, he attempted to write rightside up. However, for the first three months when left alone he would do all of his work inverted. At the time the writer investigated this case, December 21, 1934 Arthur was making rapid improvement in correcting his difficulty. With a copy before him, he was writing correctly. When he had no copy he was in a state of doubt until after he got started. Frequently he would start writing upside down, then he would stop and erase and then continue writing correctly.

The writer's attention was first called to this case about the middle of November at which time he suggested to the teacher the following: Be patient and sympathetic with the child; do not make him over conscious of his peculiarity but merely call his attention to the correct way to write; and to keep a copy before him until he had reversed his writing. She has followed these instructions and the correction seems to be taking place normally and without any trouble developing. At his present rate of improvement, his difficulty should be completely corrected in five or six months. Samples of his work are given in figures 1 and 2.

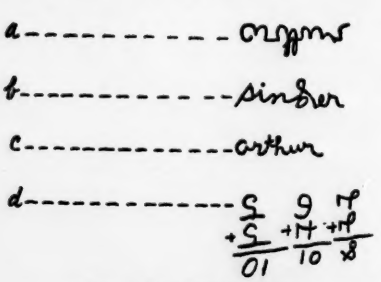

FIG. 1. SAMPLES OF WORK

a. Writing, first of November. *b*. last of November. *c*. December 21st. *d*. Number work.

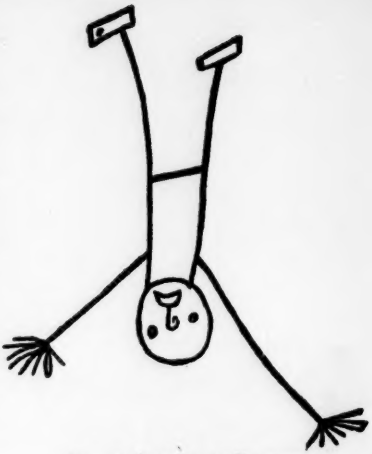

FIG. 2. SAMPLE OF DRAWING

TESTS GIVEN AND RESULTS

(a) Visual acuity. The Lowell test and the Seitz test for children and illiterates were used. His vision was normal. The child had no difficulty in reading hand writing on the board from any position in the room.

(b) Intelligence test. He was given the Stanford Revision of the Binet-Simon Tests. This gave him an Intelligence Quotient of .95.

(c) Brain dominance:

1—Handedness:	Response
Cutting with shears	R
Winding a spool	R
Throwing a ball	R
Batting with a club	R
Sweeping	R
Shoveling	R
Easy reaching	R

Energetic reaching	R
Eating	R
Thumb up	R
Receiving	R
2—Footedness:	
Standing on one foot	R
Kicking	R
3—Earedness: Straining to listen	L
4—Eyedness: Paper-hole test (every time)	L

(d) Reading. The boy could read familiar material from his reading book as well bottomside up as rightside up. With new or less familiar words he preferred to have the book rightside up.

Summary

1—This child seems to be average in every way.

2—He is 82 months old with an IQ of .95.

3—He tests dominantly right handed.

4—He had had practically no training in writing or drawing prior to entering school. He has now had four months in school.

5—His first attempts in writing and drawing in school were inverted.

6—He is making steady improvement with the following treatment: The teacher is patient and sympathetic; she tries to keep him from being over conscious of his difficulty; and she encourages him to write from a copy.

7—No signs of stuttering or any other difficulty has appeared.

MARION LEROY BILLINGS

Unilateral Sighting Preference

IN AN analysis of 18 studies on ocular dominance which have appeared in the literature it was found that the percentage of right eyedness varied from fifty-five per cent to ninety per cent, left eyedness from six per cent to thirty-three per cent, and impartial eyedness from zero to twenty-six per cent. It is the purpose of this article to present data which indicate that the variations are probably due to the criteria set up by the different investigators.

In the present investigation a variety of commonly used unilateral sighting tests were used, such as pointing with the finger, sighting through a conical shaped tube, peeping through a hole, looking through a mailing tube, and sighting through a hole in a square piece of card board. The subjects were all elementary school children.

Thirteen opportunities were given for sighting with the conical tube, 6 opportunities by pointing, 3 with the square, 2 with the mailing tube, and 1 with the peep test. The above-mentioned tests, together with several others of a similar nature, were then arranged in a battery so that a special group of subjects had 45 opportunities to make the unilateral sighting performance.

A subject was considered right eyed if he sighted invariably with the right eye regardless of the number of opportunities for sighting and left eyed if he sighted invariably with the left eye. Any variation from this consistency listed the subject as impartial eyed. This is wholly an arbitrary standard

but it is our opinion that the variations in the results of other investigators are due to the fact that they have not agreed upon such an arbitrary standard.

TABLE 1

The percentage of eye preference

NUMBER OF SIGHTINGS	NUMBER OF SUBJECTS	RIGHT EYE	LEFT EYE	IMPARTIAL EYE
		per cent	*per cent*	*per cent*
1	222	65.32	34.68	
2	538	62.49	30.85	6.66
3	784	61.61	33.16	5.23
6	786	57.40	29.72	12.88
13	739	46.68	20.58	32.74
45	113	38.05	12.40	49.55

It is seen from table 1 that as the number of opportunities for sighting increases and the criterion remains constant the percentage of eye preference varies. If only one opportunity is given all subjects must be either right eyed or left eyed. But with two or more opportunities impartial eyedness begins to appear. By increasing the opportunities indefinitely a point is eventually reached, theoretically, where all subjects would be impartial eyed.

In brief, any investigator can take any set of data and by varying the criterion of consistency can vary the percentage of eye preference. Consequently the data of no two investigators are comparable unless the number of sighting opportunities and the criterion are stated, and are in agreement.

BLAKE CRIDER

The Accuracy of Mothers' Reports on Birth and Developmental Data

M. K. Pyles, H. R. Stolz and J. W. Macfarlane

THE present study aims to investigate the accuracy with which facts concerning children's early development are reported by mothers one to two years after the developmental period. No previous quantitative investigation of this problem has been made, although physicians, clinical psychologists, nursery school teachers (1, 6, 8) *et al.* currently depend upon the mothers' reports of the birth and early development of the children with whom they are concerned. Research workers have been interested in ascertaining information even more exact than that required by clinical workers on certain groups of children. Wilson and Jones (10), Carter (2), and others, used mothers' retrospective reports in considering intra-pair differences in twins on such items as "weight at birth," "length of pregnancy," etc. Terman's comparisons of the early development (prenatal and birth conditions, age of first tooth, and age of walking) of "gifted" children with a normal sample are based on mothers' reports (7). Another type of investigation in which mothers' reports are used, is the consideration of the prenatal and neonatal handicapping of the first born in relation to that for later births (4). Inasmuch as such extensive use has been made and probably will be made of such reports, a careful determination of their accuracy appears desirable. In addition, consideration should be given to the relation between the mother's intelligence or education and the accuracy of her reports, since several investigators have assumed this relationship to be positive (3, 7). Terman writes:

> "In judging the value of the information derived from parents, it is necessary to take account of the superior intelligence and education of the families represented in our group [of gifted children]."

A favorable opportunity to consider the accuracy of mothers' retrospective reports on developmental data is available in a cumulative study (5) made at the Institute of Child Welfare of the University of California. The 252 children included in this study are a representative sample, with respect to certain socio-economic factors, of the children living in Berkeley, California; since this group of 252 children is a representative sub-sample with respect to certain socio-economic factors (parents' nationality, income, father's occupation, socio-economic rating, neighborhood and mother's age and education) of the children included in the Berkeley Survey. The Berkeley Survey is comprised of every third

child born in Berkeley over an eighteen-month period, 1928–1929 (9). The accuracy of mothers' later reports of their children's development was determined for this group, by comparing the mothers' reports when the children were aged 21 months with earlier records of the same developmental data.

The early or *primary records* are based on data obtained by the Institute's public health nurse (Miss Agnes Covalt) during the first year of the child's life. The primary data may be considered to have a high degree of accuracy and completeness since they were systematically taken at approximately the time of the event and involved checks through references to several sources of information (hospital, physician and mother). Soon after the children were born, circumnatal and pregnancy histories were obtained from attending physicians, hospital records, and mothers' own reports. Other primary data were secured by the nurse who visited each family at three-month intervals during the first year of the child's life and who recorded certain aspects of the child's development.

For purposes of comparison with the primary records, *later* reports of these same developmental items were obtained from the mother during the child's 21-month physical examination at the Institute. The questions were asked by the examining physician.

Items for which there are available both primary records and 21-month reports are:

Birth and maternity:

(i) Physical condition of mother during pregnancy
(ii) Duration of gestation
(iii) Duration of labor
(iv) Instruments at delivery
(v) Injury to mother during delivery
(vi) Weight at birth

Development during first year:

(vii) Age walked alone
(viii) Age first tooth appeared
(ix) Weight at one year
(x) Disease history during first year

AGREEMENT BETWEEN THE 21-MONTH REPORTS AND THE PRIMARY RECORDS

Several methods of comparing the 21-month reports and the primary records have been used because it was believed that the different methods offered supplementing information as to the agreement between the two sets of records.

In figure 1 the percentage of mothers whose reports are accurate (primary and 21-month reports are in exact agreement), is contrasted with (a) the percentage whose 21-month reports deviated by more or less than one standard deviation from the primary records (see table 1), and with (b) the percentage unable to recall these items when the children were aged 21 months. It may be seen that certain items such as "birthweight" and "duration of gestation" are accurately reported by a large percentage of the mothers; whereas "age at which child walked alone" and "age first tooth appeared" are *less* accurately reported; and "duration of labor" and "weight at 12 months" are least accurately reported. When the children were aged 21 months, as many as 65 per cent of the mothers were unable to make any statement about their children's 12-month weight.

Agreement coefficients, or the correlations between the 21-month reports and the primary records, are shown in table 1 (column 3). The item which is most accurately reported, with respect to the primary records, is the child's "weight at birth"; the correlation for this item is .96. Agreement coefficients for "age walked alone," "age first tooth appeared" and "weight at 12 months" are approximately .80. It is interesting to note that the comparatively few mothers (35 per cent of the cases) who are able to recall "weight at 12 months," report this item with a fair degree of accuracy. The item which is least accurately reported is "duration of labor"; here the correlation is only .61. The agreement between the primary records and the 21-month reports for "duration of labor" is probably low because of differences in the understanding of what constitutes "labor"; that is, whether one or all three stages should be included in the report of "duration of labor." On the whole, these correlation coefficients appear higher than might be expected from the percentage figures presented in figure 1. This suggests the inaccuracies which may be involved where agreement coefficients are as high as .80.

The differences between the means for the two sets of records are given in column 8 (table 1). These differences show whether or not there are definite tendencies for the mothers to remember the children as heavier or lighter than is indicated in the primary records; and whether the recall of such items as "age walked alone" and "age first tooth appeared" is in the direction of making the children appear more precocious than is suggested by the records obtained during the first year. The minus signs show that the mothers tend to underestimate the "duration of labor," "weight at birth" and "weight at 12 months," and to underestimate (thereby suggesting precocity) "age walked alone" and "age first tooth appeared." A further indication that mothers tend

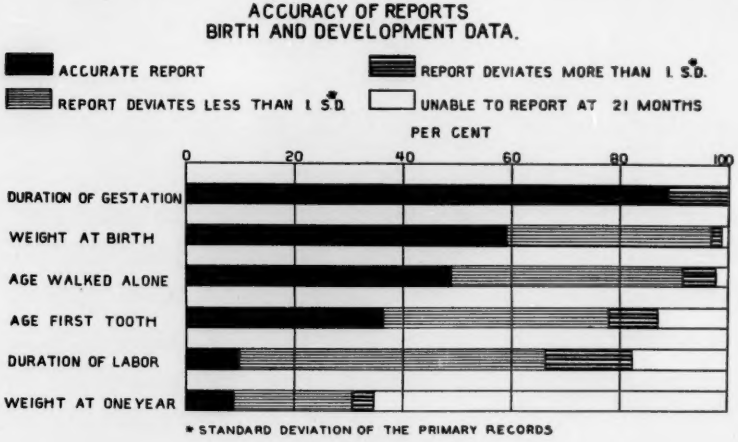

FIG. 1

to report in the direction of precocity for these latter two items is to be found in the comparison of the actual number of inaccurate reports which are overestimations (relative to the primary records) with the number which are underestimations. If there were no tendency for mothers to remember their children as more or less precocious, approximately 50 per cent of the inaccurate reports would be under- and 50 per cent would be to report their children as lighter or heavier at birth; 47 per cent and 53 per cent respectively over- and underestimated on this item.

Returning to the data presented in column 8 of table 1, it is found that the average distortion in the direction of precocity is .4 of a month for both "age child walked alone" and "age first tooth appeared." The reader may wonder at this point whether the mean difference of −.4 of a month (for "age

TABLE 1

Agreement between the 21-month reports of the children's development and the primary records

DEVELOPMENTAL ITEM	NUMBER OF CASES*	AGREEMENT COEFFICIENT	PRIMARY RECORDS		21-MONTH REPORTS		MEAN DIFFERENCE (DIFF. BETWEEN (6) AND (4))	ABSOLUTE DIFFERENCE (REGARDLESS OF DIRECTION)
			Mean	S.D.	Mean	S.D.		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		r						
Duration of labor (in hours).....	158	.61	8.57	5.28	8.23	5.74	−.34	3.5
Weight at birth (in ounces).....	223	.96	122.62	20.41	122.26	20.97	−.36	2.2
Weight at 12 months (in ounces)..	74	.79	367.74	49.10	358.82	48.52	−8.92	18.7
Age walked alone (in months).....	214	.84	13.68	2.16	13.29	2.20	−.39	.7
Age first tooth (in months).....	187	.80	7.71	2.08	7.30	2.19	−.41	.9

* The number of cases varies for the different items because a certain number of the mothers were unable to recall one or more of these facts at the 21-month interview.

overestimations. Actually, 75 per cent of the inaccurate reports for "age walked alone" and 72 per cent of the inaccurate reports for "age first tooth appeared," are in the direction of precocity (underestimations). That is, almost three times as many mothers erring on these two items, erred in the direction of making their children appear *more* precocious as erred in the direction of making their children appear *less* precocious. No systematic tendency was noted for mothers walked alone" and "month of first tooth") may not be due to a systematic tendency for mothers to report to the nearest month (*e.g.* 12.5 months reported simply as "12 months"). Examination of the data, however, reveals that although the majority of the discrepancies of one month or less were in the direction of suggesting precocity, an even larger proportion of discrepancies of *more* than one month were in this direction. In other words, whereas *27* mothers reported that their

children walked from 1.5 to 5 months *earlier* than the primary records suggest, only *8* mothers reported that their children walked from 1.5 to 5 months *later* than the primary records indicate. Similar results were obtained for "age of first tooth." Terman, comparing his "gifted" group with Mead's normal sample on "age of first walking," noted that on the average the "gifted" children walked about one month earlier than the normal children (7). Terman states that the data on the "gifted" group are "subject to the ordinary errors of report due to faults of memory and observation," but that "the coöperation of the parents was such that it is believed the question of intentional falsification of report need not be raised." It is not believed that there was intentional falsification in the 21-month reports in the present study, because of the mothers' coöperativeness and understanding that their reports were to be used only for research purposes. A slight tendency was noted for mothers who reported in the direction of precocity for one item to report in the *opposite* direction for the other item; the coefficient of contingency between the direction of the discrepancies for "age walked alone" and "age of first tooth" is −.17; or −.22 when corrected for broad categories. Although no systematic tendency was noted for mothers to report their children as heavier at birth and heavier at 12 months in the later reports, mothers who did report their children as heavier for one item tended to err in the same direction on the other item (coefficient of contingency +.26, or +.34 when corrected for broad categories).

In addition, table 1, column 9, presents the absolute differences or the *average discrepancies* (regardless of direction) between the primary records and the 21-month reports. The average discrepancies suggest the disagreement which might be expected for each item from individual mothers. The discrepancy to be expected on the average, in the 21-month report of "age of first tooth" is .9 of a month, and for "age walked alone" .7 of a month. The discrepancy in "birthweight" of 2 ounces is of little significance; but in "duration of labor," the discrepancy of three and a half hours appears significantly large both clinically and statistically (see column 5).

The statistical methods used to indicate the agreement between the primary records and 21-month reports for the foregoing items were not applicable to the following: "physical condition of mother during pregnancy," "disease history during first year," "injury during delivery," "use of instruments at delivery." These four items have therefore been considered separately as follows.

Physical condition of mother during pregnancy

On the basis of the obstetrician's and hospital's records of the pre- and circumnatal conditions, the mother's "health during pregnancy" was rated by a physician (Herbert R. Stolz) as either satisfactory or unsatisfactory. Dr. Stolz's criterion in assigning these ratings was that the mother's condition was judged unsatisfactory if it were

such that it might have interfered with the normal development of the child (examples of unsatisfactory conditions are infected tonsils, thyroid enlargement, severe albuminuria, etc.).

The mothers' responses regarding their health during pregnancy, secured when their children were aged 21 months, fell quite readily into a 7-point scale ranging from "Very poor" to "Excellent." In table 2, the 21-month reports of the group of mothers whose physical condition was considered satisfactory (on the basis of physicians' and hospitals' records) are compared with the group whose physical condition was considered unsatisfactory. The biserial r between the early records and the 21-month reports is .22. It is of interest to note that of those mothers whose condition (according to the primary records) was unsatisfactory, as many reported that their health was "Excellent" or "Very good" as reported that their health was "Poor" or "Very poor."

TABLE 2

Physical condition of mother during pregnancy

Comparison of the 21-month reports for a group of mothers whose physical condition was considered *satisfactory* (according to the primary records), with a group whose physical condition was considered *unsatisfactory*

MOTHER'S REPORT WHEN CHILD AGED 21 MONTHS		PRIMARY RECORDS PHYSICIAN'S CLASSIFICATION					
		Satisfactory		Unsatisfactory		Total	
Rating		n	Per cent	n	Per cent	n	Per cent
7	"Excellent"	9	*5*	3	*7*	12	*5*
6	"Very Good"	30	*16*	6	*13*	36	*15*
5	"Good"	109	*57*	18	*39*	127	*53*
4	"Fairly Good"	14	*7*	4	*9*	18	*8*
3	"Not Well"	14	*7*	6	*13*	20	*8*
2	"Poor"	11	*6*	5	*11*	16	*7*
1	"Very Poor"	5	*3*	4	*9*	9	*4*
Total		192	101	46	101	238	100
Mean Rating		4.76		4.24		4.66	
S. D.		1.26		1.67		1.36	

Disease history during first year

The nurse who visited the families at 3-month intervals during the first year of the child's life, asked about the illnesses or handicaps that the child had experienced during the preceding three months. On the basis of the nurse's records, the disease history of the children during infancy was rated by Dr. Stolz on the following 5-point scale:

A rating of 5 was given to children who had suffered illnesses or physical handicap of such kind, frequency, severity, and duration as to justify the assumption that development was *markedly* modified thereby.

A rating of 4 was given to children who

had suffered illnesses or physical handicap of such kind, frequency, severity, and duration as to justify the assumption that development was *definitely* modified thereby

A rating of 3 was given to children who had suffered illnesses or physical handicap of such kind, frequency, severity, and duration as to justify the assumption that development was probably *slightly* modified thereby.

A rating of 2 was given to children who had suffered illnesses or physical handicap of such kind, frequency, severity, and duration as to be considered *insignificant* in relation to development.

A rating of 1 was given to children for whom no illness or physical handicap was reported.

When the children were aged 21 months, the physician who gave the physical examination at the Institute again asked the mothers about the children's illnesses during the first year. Table 3 presents the disease ratings for children whose mothers reported the occurrence of *some illness* and, in comparison, ratings of those children whose mothers reported the occurrence of *no illness* during the first year. The biserial r between the disease ratings and mothers' reports at 21 months is .62. It is encouraging to note that the mothers of all children whose disease records deserved a rating of 5 (having illness or physical handicaps of such kind, severity, frequency and duration as to justify the assumption that development was markedly modified thereby) reported the occurrence of at least *some illness* during the first year at the 21-month interview. On the other hand, at the 21-month interview the mothers of two children given ratings of 4,[1] and of twenty-eight children given ratings of 3 failed to report the occurrence of any illness during the first year.

TABLE 3

Disease rating during first year

Comparison of the disease ratings of the children whose mothers reported (at 21 months) some illness as having occurred during the first year, with those of children whose mothers reported no illness

DISEASE RATING (BASED ON NURSE'S RECORDS OF DISEASE HISTORY IN FIRST YEAR)	MOTHER'S REPORT AT 21 MONTHS					
	No illness		Some illness		Total	
	n	Per cent	n	Per cent	n	Per cent
5			8	*7*	8	*3*
4	2	*2*	19	*16*	21	*9*
3	28	*24*	53	*43*	81	*34*
2	57	*48*	42	*34*	99	*41*
1	31	*26*			31	*13*
Total.....	118	100	122	100	240	100
Mean Rating....	2.01		2.94		2.48	
S.D.....	.75		.87		.94	

[1] The children given the ratings of 4 had respectively asthma and several colds, and whooping cough and eczema during the first year.

Instrumental delivery

Both primary records and the 21-month reports as to whether or not instruments were used in delivering the child, were available for 225[2] of the mothers. Fifty-four (or 24 per cent) of the 225 mothers were delivered with instruments. Comparison of the 21-month reports with the primary records shows that 67 per cent, or only *two-thirds*, of the 54 mothers delivered with instruments reported this fact at the 21-month interview. The reader may wonder, at this point, whether all of these 54 mothers were aware that instruments were used. It is quite possible that some were not; however, the fact still remains that a large number of mothers for whom there are primary records of the use of instruments failed to report this fact at a 21-month interview.

Injury to the mother at the birth of the child

Any laceration, tears or an episiotomy have been considered as injuries. The mothers' reports were frequently in the form of the number of stitches which had to be taken. According to the primary records, approximately two-thirds of the mothers were injured. When the children were aged 21 months, only 23 per cent of the mothers who were injured reported this fact.[2]

DISCUSSION

Because of the frequent visits and questionings of the Institute nurse, the mothers of the children included in this study were probably more conscious of their children's development than an entirely unselected group would be. For this reason, the agreement coefficients may appear too high. On the other hand, as has been mentioned, the mothers may not always have been informed of certain of the data in the primary records (health during pregnancy, use of instruments at delivery and injury during the birth of the child). There seems, however, to be no reason to expect that another group of mothers would be better informed than this one. It is interesting to note, in this connection, that in the group studied by Terman (7), *15 per cent* of the mothers of "gifted" children reported the use of instruments at delivery; this percentage is closer to the per cent obtained on the basis of the 21-month reports, *14 per cent*, than to the per cent based on the primary records, *24 per cent*.

A further point which might be mentioned is the apparent tendency for mothers to forget certain of the difficulties encountered with their children. Although *some* of the mothers may not have been aware that instruments were used or that they were injured during delivery, it seems unlikely that the number would be as great as is indicated in the 21-month reports. In other words, it would seem that there is a tendency for certain mothers to minimize or to unconsciously forget these difficulties. Other evidence for this tendency is to be noted in the number of illnesses had by the child during infancy which are *not* reported by the mothers at the 21-month interview. The forgetting of difficulties may be contrasted with

[2] This does not include cases where there was a Caesarean section.

the tendency to recall that the children "walked" or had their "first tooth" at an earlier age than the primary records indicate.

FACTORS RELATED TO ACCURACY OF REPORT

A consideration of practical and theoretical importance is the extent to which the *same* mothers give inaccurate reports on these different developmental items. If certain mothers consistently give accurate and other mothers consistently give inaccurate reports, the *intercorrelations of the discrepancies* between the primary records and the 21-month reports would be high. The intercorrelations for variables "month walked alone," "month first tooth," "birthweight," "weight at 12 months," and "duration of labor," were computed and found to range from $-.18$ to $+.27$. The highest correlations were obtained between the extent of the discrepancies in the reports of "age first tooth appeared" and "birthweight" (r .27), and "age first tooth appeared" and "age walked alone" (r .22). The intercorrelations in general are extremely low and approximate a zero relationship. Apparently within the range of ability considered in this study (a representative sample of mothers living in a moderately sized city), mothers show no general tendency to give accurate or widely discrepant reports on all items.

It seemed not unlikely that mothers of several children would have more difficulty than mothers of singletons in remembering the different aspects of their child's development. Correlations were therefore computed between the order of birth and discrepancies between the primary records and the 21-month reports. This analysis revealed a tendency for mothers of *several* children, in comparison with the mothers of singletons, to be *less accurate* (as evidenced by larger discrepancies) in their later reports of "weight at birth" (r .24) and "age of first tooth" (r .22). No relationship was found between birth order and inaccuracy of report on "age walked alone" (r .05), nor between birth order and inaccuracy of report on "duration of labor" (r .09). The relation between order of birth and accuracy of report on "birth weight" and "age of first tooth" may be attributable to the (a) lower intelligence of mothers of large families, or (b) confusion of data for different children. It appears that both these factors are operative. The correlation between the mother's education and birth order is $-.15$ (indicating lower intelligence of mothers of large families); and the correlation between mother's education and accuracy of report of "birth weight" tends to be positive (see next paragraph). These coefficients, however, do not entirely account for the relation between birth order and the discrepancies in the reports of "weight at birth" and "age of first tooth;" in other words, there is some evidence that mothers of several children tend to be less accurate in their later reports when the factor of education or intelligence is kept constant. A slightly greater tendency was observed for primiparae than for multiparae to err in the direction of precocity for "age walked alone" (78 per cent of the multiparae as compared with 71 per

cent of the primiparae) and "age first tooth appeared" (73 per cent as compared with 68 per cent).

The education of the mother, in terms of the number of years of schooling, was correlated with the accuracy (smallness of the discrepancy) for the different items. A correlation coefficient of .28 was obtained between mother's education and the accuracy of the report of "weight at birth." This correlation appears comparatively high in view of the large number of completely accurate reports for this item (fig. 1) and the restricted range of discrepancies. However, no relationship was found between mother's education and the accuracy of report on any other item. Ratings of the mother's intelligence were available for half of the sample (126 cases) included in the present study. Correlations between these ratings and the accuracy of reports tend to be similar to those obtained for mother's education. A positive correlation of .17 was found for the ratings of the mother's intelligence and the accuracy of report of the child's "birthweight."

The per cent of mothers unable to recall these developmental facts at 21 months is given in figure 1. It was thought possible that the less educated mothers might be able to recall fewer facts about their children's early development. A coefficient of contingency was therefore computed between fewness of years of schooling and the number of items on which mothers were "unable to recall" (a number of mothers were unable to recall as many as three of these items). This coefficient was found to be .28 (not corrected for broad categories), indicating a very slight degree of relationship.

SUMMARY AND CONCLUSIONS

1. In a representative sample of 252 children living in a superior urban community, comparisons were made between mothers' reports of their children's early development at a 21-month physical examination, and primary records taken during the first year. The agreement between the 21-month reports and the primary records may be summarized as follows:

Birth and maternity:

(i) *Physical condition of mother during pregnancy:* The biserial r between the 21-month reports and the primary records is .22, indicating extremely low agreement.

(ii) *Duration of gestation:* The 21-month reports and the primary records are in exact agreement for 89 per cent of this "normal sample" of mothers.

(iii) *Duration of labor:* The 21-month reports are in exact agreement with the primary records in only 10 per cent of the cases. The correlation between the two sets of records is .61 and the average discrepancy is 3.5 hours.

(iv) *Use of instruments at delivery:* Only two-thirds of the mothers who were delivered with instruments reported this fact at the 21-month interview.

(v) *Injury to mother during delivery:* Only 23 per cent of the mothers who were injured at the birth of the child reported this fact at the 21-month interview.

(vi) *Weight at birth:* The 21-month reports are in exact agreement with the primary records in 59 per cent of the cases; the corre-

lation between the two sets of records is .96 and the average discrepancy is approximately two ounces.

Development during first year:

(vii) *Age walked alone:* The 21-month reports of 49 per cent of the mothers are in exact agreement with the primary records; the correlation between these records is .84 and the average discrepancy .7 of a month.

(viii) *Age first tooth appeared:* This item is accurately reported by 36 per cent of the mothers; the correlation between the two sets of records is .80 and the average discrepancy .9 of a month.

(ix) *Weight at one year:* The 21-month reports of this weight are in exact agreement with the primary records in 9 per cent of the cases. Sixty-five per cent of the group were unable to recall this item at the 21-month interview. The average discrepancy, for those who were able to give information, was 19 ounces and the agreement coefficient .79.

(x) *Disease history during first year:* The biserial r between the child's disease ratings and the mother's reports at 21 months as to the occurrence of illness during the first year is .62.

In view of the following facts, these results are, if anything, rather too favorable as to the accuracy of mothers' reports, (a) although a representative sample of Berkeley, the sample is superior in education and intelligence to an unselected urban sample; (b) the group is more awake to developmental problems, more "child conscious" than ordinary groups because of the repeated visits of the nurse; (c) the later reports were obtained when the children were 21 months and not, as commonly, when the children are of school age or adolescent.

2. No general tendency was found for mothers to give either accurate or widely discrepant reports on *all* items.

3. Mothers tended to err in the direction of suggesting precocity in the 21-month reports of "age walked alone" and "age of first tooth."

4. A mother with several children shows a slightly greater tendency, on the average, to err than a mother with only one child, in reporting "birthweight" and "age of first tooth." Mothers of first-born children are more apt to err in the direction of suggesting precocity than are the mothers of later born.

5. A correlation of .28 was obtained between the accuracy of report of "weight at birth" and mother's education; and a coefficient of contingency of .28 was obtained between the number of items recalled at 21 months and mother's education. No other significant relation was found between either the intelligence ratings or education of the mothers and the accuracy of their reports.

6. The results show a slight but general tendency for mothers to forget some of the difficulties of rearing young children: mothers tend to forget the illnesses and disturbances suffered during pregnancy; they tend to forget the injuries received at the birth of the child and use of instruments at that time; slight illnesses of the child during infancy are forgotten; and finally, mothers tend to remember that their children walked and had their first teeth at an earlier age than the primary records indicate.

REFERENCES

(1) BLATZ, W. E. AND BOTT, H.: Parents and the preschool child. William Morrow and Co., 1928.

(2) CARTER, H. D.: Case studies of mature identical twins. J. Genet. Psychol., 1934, 44.

(3) HOLLINGWORTH, LETA S.: Gifted children. The Macmillan Co., 1926.

(4) JONES, H. E. AND HSIAO, H. H.: Pregnancy order and early development. Child Develop., 1933, 4, 2.

(5) MACFARLANE, J. W.: Studies in child guidance: I. Methods of data collection and organization. Manuscript.

(6) Manual of Nursery School Practice, Iowa Child Welfare Research Station, Univ. Iowa Press, March, 1934.

(7) TERMAN, L. M. *et al.*: Genetic studies of genius. V. 1, Stanford Univ. Press, 1925.

(8) Washington Child Research Center, Washington, D. C. 1931.

(9) WELCH, F. M. *et al.*: The Berkeley survey: A study of the socio-economic status of four hundred Berkeley families in years 1928 and 1929. Manuscript.

(10) WILSON, P. T. AND JONES, H. E.: A study of like-sexed twins: 1. The vital statistics and familial data of the sample. Human Biol., 1931, 3, 1.